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Development of Multi Sectoral Energy Plan and Decision Support Tool for the State of Odisha

Energy Plan for Odisha





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List of Abbreviations

Abbreviation	Full Form
AMI	Advanced Metering Infrastructure
AMSC	Agriculture Machinery Service Centres
BAU	Business as Usual
BBMB	Bhakra Beas Management Board
BEE	Bureau of Energy Efficiency
BIPV	Building Integrated Solar PV
CAGR	Compound annual growth rate
CBG	Compressed Biogas
CEA	Central Electricity Authority
CGD	City gas distribution
CO2	Caron dioxide
CO2e	Caron dioxide equivalent
CoE	Centre of Excellence
Cr	Crore
CSO	Civil society organizations
DC	Designated Consumers
DISCOM	Distribution Company
DoP	Department of Power
DPMS	Development Permission Management System
DR	demand response
DRS	Demand Response System
DSM	demand side management
EP	Energy Plan
ECBC	Energy Conservation Building Code
EE	Energy Efficiency
EEPS	Energy Efficient Pump Set
EESL	Energy Efficiency services ltd
ELV	End-of-life vehicles
EP	Energy Plan
ESCO	Energy service company
EV	Electric Vehicle
FBC	Fluidized Bed Combustion
FCV	Fuel Cell Vehicles
FCV	Fuel Cell Vehicles
FY	Financial Year
Gcal	Giga Calorie
GCV	Gross calorific value
GHG	Green House Gases
GIS	Geographical Information System
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GMADA	Greater Mohali Area Development Authority
GOI	Government of India
GSDP	Gross State Domestic Product
GSVA	Gross State Value Added
GW	Gigawatt

GWh	Gigawatt Hour
HH	Household
IBEF	India Brand Equity Foundation
IGEN	The Institution of Green Engineers
IISD	International Institute for Sustainable Development
INR	Indian Rupee
IPDS	Integrated Power Development Scheme
IPP	Independent Power producers
JNNSM	Jawaharlal Nehru National Solar Mission
KV	Kilovolt
kWh	Kilo Watt hour
LC	Low Carbon
LMV	Light Motor vehicle
LNG	Liquified Natural gas
LPG	Liquified petroleum gas
LPR	Low Power Radio Frequency
MDM	Mid-day meal
MNRE	Ministry of New and Renewable Energy
MoPNG	Ministry of Petroleum and Natural Gas
MSME	Micro Small and Medium enterprises
MSW	Municipal Solid Waste
MT	Metric Tonne
MtCO2	Million tonne of CO2
Mtoe	Million tonne of Oil Equivalent
MU	Million Units
MW	Mega Watt
NMEEE	National Mission for Enhanced Energy Efficiency
NRSE	New and Renewable Sources of Energy
OMC	Oil Marketing Companies
OREDA	Odisha Renewable Energy Development Agency
PAT	Perform Achieve & Trade
PES	Primary Energy Supply
PLF	Plant load factor
PM KUSUM	Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan Yojana
PMU	Project Management Unit
PMUY	Pradhan Mantri Ujjwala Yojana
PNG	Piped natural Gas
PV	Photo Voltaic
PVC	Polyvinyl chloride
R&D	Research and Development
RD&P	Rural Development and Panchayats
RE	Renewable Energy
RES	Reference Energy System
SAPCC	State Action Plan on Climate Change
SCADA	Supervisory Control and Data Acquisition
SDG	Sustainable development Goals
SGST	State Goods and Service Tax
SHG	self-help groups

SHR	Station heat rate
SLDC	State Load Dispatch centers
SPEED	State Partnership for Energy Efficiency Demonstrations
T&D	Transmission and Distribution
toe	Tonne of Oil equivalent
TOT	Training of Trainers
TPD	Tonnes per day
TWh	Tera Watt Hour
UJALA	Unnat Jyoti by Affordable LEDs for All
USD	United states Doller
VFD	Variable frequency drive
WAM	Wide Area Measurement

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1. Background of the Project

Odisha has shown significant economic growth over the past five years with the state's GSDP increasing at a CAGR of 10.24% between 2016-17 to 2021-22 (IBEF 2022). Further, significant growth has been observed in the State economy due to implementation of various industry sector friendly and agriculture sector friendly policies, promotion of service sector and overall economic growth in the country.

The figure below compares the economic performance of the states of India for a seven year period (FY12-13 and FY19-20) based on the per capita income in the base year and the average per capita income growth. Odisha is among those states which has improved its ranking on per-capita income and has grown at a higher rate when compared to states such as Chhattisgarh, Rajasthan, Jharkhand, Uttar Pradesh and Bihar.

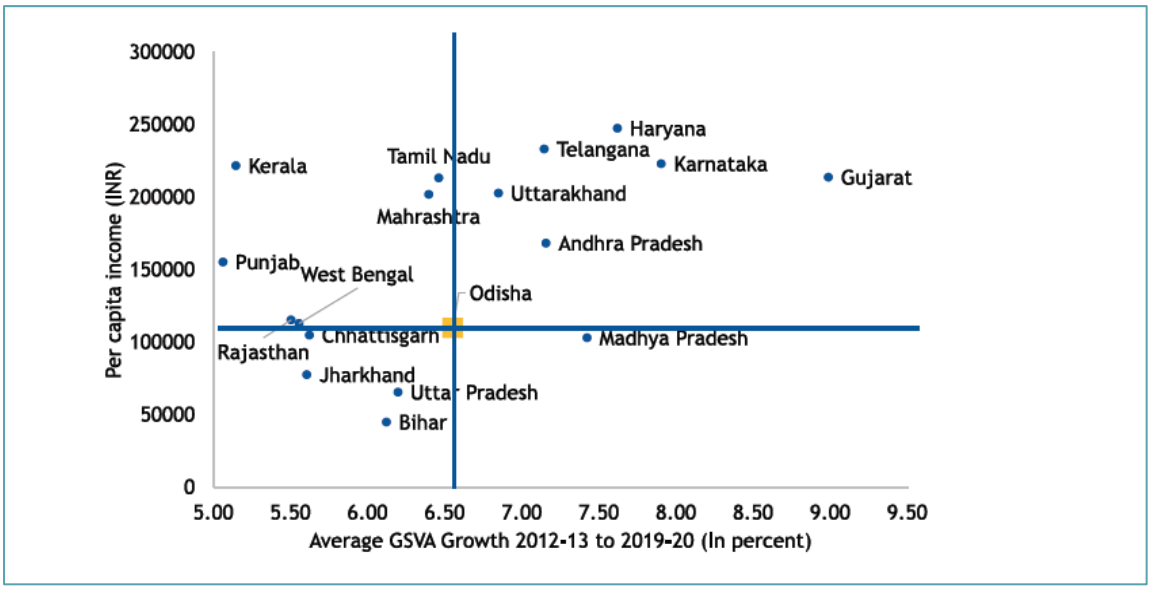


Figure 1: Comparison of State economic performance (Source:

In case of Odisha, economic growth and energy consumption are correlated (Topolewski 2021), which further indicates that energy availability and consumption is essential for the state to move up in the ladder of economic and social development. Energy is one of the major resources in the economy which integrates all other sectors in one common thread and thus a comprehensive assessment and planning for energy production and consumption in the economy is an essential task.

Apart from the current issues plaguing the power sector (such as heavy reliance on thermal-based power generation, etc.), the broader energy sector in the state is poised to go through a transformation in the coming years. Any endeavour to draft the Energy Plan, which is also futuristic in nature, has to take into cognizance of these emerging trends.

The State Government and its functionaries acknowledge the implications of the above on the energy scenario of the state and there has been clear communication of the intent of individual departments in implementation of clean technologies (viz. increased penetration of CBG, faster adoption of solar pumps and energy efficient cold rooms, use of densified biomass as an input in industries rather than coal, use of green hydrogen, promotion of electric vehicles in the state and increased penetration of rooftop solar in buildings). Development of State Energy Plan (EP) will help to communicate this intent of the State Government as well as how it intends to honour its commitments, as defined in the Odisha Renewable Energy Policy 2022, in energy supply and demand sectors within a given timeline.

The EP for Odisha, developed in a rational, scientific and data-driven fashion, will aid the policy makers of the state in planning and optimally allocating resources for developing the state's energy sector for the next 15-20 years.

- In a sense, EP will build on existing policy and regulatory priorities of the State, provide a unified energy agenda, will be forward looking and take into account emerging trends and realities.
- The EP will go beyond capacity/supply planning and will significantly focus on efficiency

1.1. Economic Profile of Odisha

The economy of Odisha is one of the largest economies in India with INR 6.40 trillion (USD 77.68 billion) in FY 2021-22 in gross state domestic product (GSDP) and a per capita GSDP of INR 127, 383 (USD 1538.07). Overall, the state's GSDP has increased at a CAGR of 10.24% between 2016-17 to 2021-22 and the per capita GSDP has increased at a CAGR of 9.98% between 2016-17 to 2021-22 (IBEF 2022)[1]. The snapshot for FY22 (in comparison to all India level) has been presented in the adjoining figure.

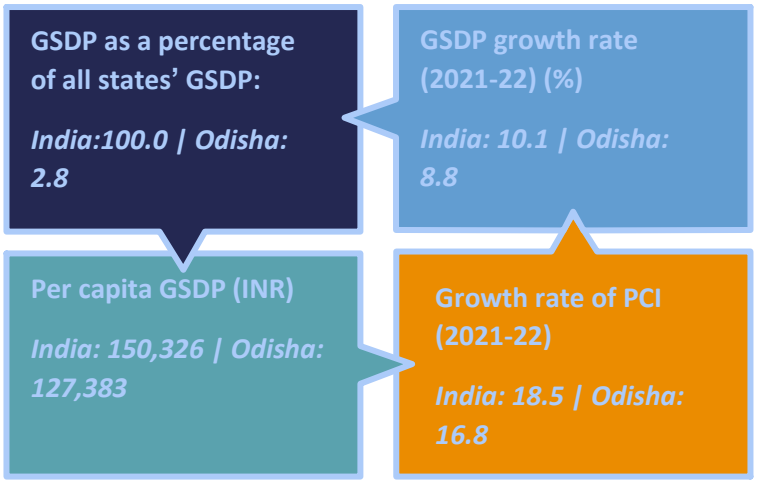
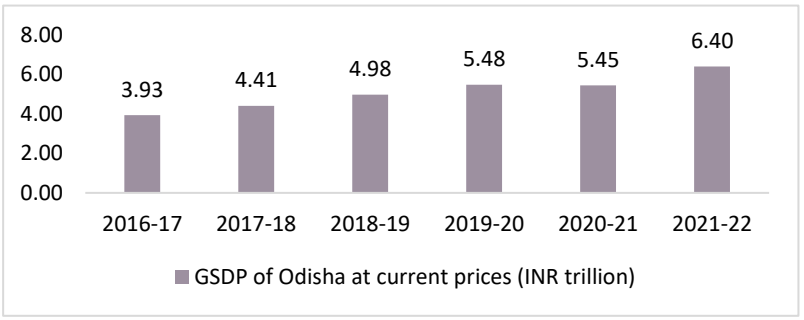


Figure 2: Key Economic figures for Odisha

The increase in GSDP can be attributed to the robust growth of the manufacturing sector in Odisha. The growth of the manufacturing sector in Odisha in FY 2021-22 is around 14.3% which is significantly higher than 5.5% at the national level. Further, Odisha has witnessed impressive growth in the mining, storage, transport and communication sub-sectors (IBEF 2022).



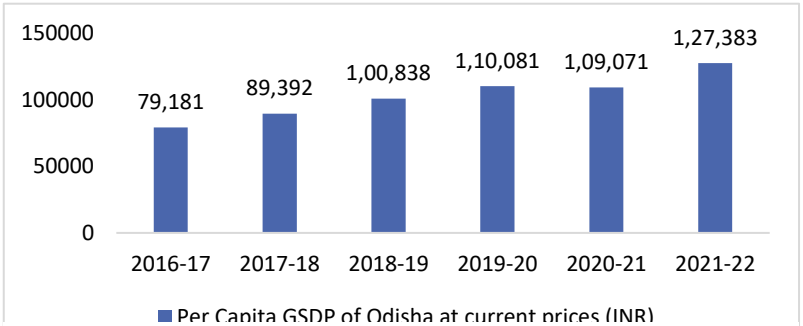


Figure 3: Odisha GSDP and per capita GSDP at current Prices

The year 2020 witnessed unrivalled turmoil with the COVID-19 virus and the resultant pandemic emerging as the biggest threat to economic growth. However, when the agriculture sector grew by only 3.3% at all India level, in Odisha, the sector grew by 7.4%. It was the only sector that contributed positively to the

[1]*In INR terms, GSDP, per capita GSDP figures are taken at current prices, Current Exchange Rate used is average of. i.e., US$ = Rs. 82.80, **operational

overall Gross State Value Added (GSVA) of the state (Economic and Statistical Organisation, Governement of Odisha 2022). In terms of the sectoral contribution to GSVA, tertiary (service) sector has been the fastest growing sector and was the largest contributor to Odisha's economy in 2021-22, with a 39.9% share in the state's GSVA. Some of the sub-sectors within the service sector has grown at a very high rate of 8.4-9.2%. The growth has been driven by transport, storage, financial services, communication, public administration, and other services. As far as the primary (agricultural) sector is concerned, it contributed 20.6% and the secondary sector (industrial) contributed 39.5% to Odisha's GSVA in 2021-22 (IBEF 2022).

1.2. Odisha State Energy Profile

The total installed capacity of the state of Odisha as of December 2022 is 12322 MW. This includes central share of 4610 MW. The main source of energy generation in the State is from thermal power plants (4,858 MW), Hydro (2163 MW) and renewable energy sources (628 MW). The breakup of the source wise installed capacity in the state of Odisha as on FY 2021-22 is tabulated below:

Table 1: Total Installed Capacity of Odisha for FY 2021-22 (in MW)

Sr. No.	Description	Value (MW)
1.	Thermal (state owned)	1740
2.	Thermal (Private - IPPs)	1686
3.	Large Hydro	2163
4.	Mini/ Micro Hydro	115
5.	Solar	443
6.	Biomass	59
7.	Share from Central sector	4610
8.	Share from other sector	1495
9.	**Total Capacity (excluding central sector and other shares)**	**6206**
10.	**Total Capacity (including central sector and other shares)**	**12311**

Source: GRIDCO

Over the years, the total RE installed capacity in the state has increased further to reach a total of 627.79 MW. Majority of this capacity comes from solar, amounting to 452.94 MW. The remaining capacity is dividing between biomass power plants, co-gen plants, mini-hydel and waste-to-energy plants. The breakup of the source wise RE installed capacity in the state of Odisha as of February 2023 is tabulated below:

Table 2: Total Installed RE Capacity of Odisha as of February 2023 (in MW)

S.No.	Project	Cumulative Achievement (MW)
1	Ground Mounted Solar Power Projects	403.56
2	Rooftop Solar Projects	21.66
4	Off grid Solar	27.72
6	Solar Power Projects	328.91
Total Solar		**852.44**
7	Biomass / Bagasse Co-generation Power Project	50.40
8	Biomass Non-Bagasse	8.82
9	Biomass Power Plants	45
10	Mini Hydel Projects	115.63
Total Non-Solar		**219.85**
GRAND TOTAL		**1072.29**

Source: CEA and Odisha SLDC

In addition, through participation in different state and national level schemes, several distributed RE projects have been developed in Odisha. Details of installed capacity / number for installations under these schemes is provided below:

Table 3: Total Installed RE Capacity / numbers as part of different schemes as of December 2022

S.No.	Project	Cumulative Achievement
1.	Biogas Plants (under NBMMP/NNBOMP)	271,752 nos.
2.	SHP project commissioned	18 MW
3.	Solar Parks (Sanctioned)	140 MW
4.	Grid Connected Solar PV Rooftop Systems	4,000 KW
5.	Solar Home Lights (Off grid SPV program)	5,274 nos.
6.	Solar Lamps (Off grid SPV program)	99,843 nos.
7.	Solar Street Lights (Off grid SPV program)	18,450 nos.
8.	Solar Pumps (Off grid SPV program)	10,292 nos.
9.	Solar Power Plant (Off grid SPV program)	2,321
10.	PM KUSUM Component A Solar Capacity Installed (Grid)	500 MW
11.	PM KUSUM Component B Agriculture Solar Pumps (Off- Grid)	5,700 nos.

Further, the total power generation as on FY 2021-22 in the state of Odisha was 29,696 GWh (excluding central and other sector share), which includes 24,061 GWh from thermal power plants (state owned and IPPs) and 1081 GWh from renewable sources of energy. The breakup of the source wise total power generation in the state of Odisha as on FY 2021-22 is tabulated below:

Table 4: Total Energy Generation in Odisha for FY 2021-22 (in GWh)

Sr. No.	Description	Value (GWh)
1.	Thermal (state owned)	8,238
2.	Thermal (IPPs)	15,823
3.	Large Hydro	4,551
4.	Renewable Sources (Solar, Biomass, Mini/ Micro Hydro, etc.)	1,081
5.	Share from Other Sectors	3,159
6.	Share from Central sector	25,225
7.	**Total Generation (excluding central & other sector share)**	**29,696**
8.	**Total Generation (including central & other sector share)**	**58,080**

Source: MoP and PwC Analysis

In terms of electricity consumption, the per capita consumption of electricity in the State has increased from near 1419 kWh in 2014-15 to 2254 kWh in 2021-22 (CEA 2022). The commercial sector is the third largest consumer of electricity in the state trailing behind domestic & industrial sectors.

- According to the Odisha Power Generation Corporation Ltd (OPGC), the **energy generation** in the state has **increased by ~19%** (i.e., from 8,577 MU in 2020-21 to 10,192 MU in 2021-22).
- Out of the total energy supplied by in 2021-22, **industry** has consumed **6,554 MU (20.7%)**, General (**mainly domestic**) has consumed **8,539 MUs (27%), Agriculture** 731 MUs **(2.31%)** and the **others** 10776 MUs **(41.69%)** (CEA 2022).
- Owing to significant improvement in power supply, the **state witnessed almost no short fall in FY22**, which is considerably lower than the national average of energy shortfall of 0.4% (CEA 2022).

- In terms of peak power requirement as well, the state has performed significantly better than the national average, as the **peak deficit has been zero compared to 1.2% of the national average in FY22** (CEA 2022). However, the state is still having certain energy deficit which corroborates the need for systematic energy planning.

The state has also engaged in energy conservation projects which mainly includes retrofitting of energy efficient LED street lighting. Under the Street Lighting National Program (SNLP), Odisha has witnessed an installation of 335,226 LED streetlights from FY 2016 to 2020 resulting in an energy saving of 224.94 MU. Moreover, Odisha has the highest distribution of the LED bulbs under the Unnat Jyoti by Affordable LED for All (UJALA) programme which resulted in an energy saving of 6557.1 MU in the same period. The details about different energy conservation measures undertaken by the state are tabulated below:

Table 5: List of different energy conservation projects undertaken in Odisha

Sr. No.	Name of the component	Project Status
1.	Street Lighting National Program (SNLP)	LED streetlights installed: 335,226
2.	LED Street Lighting Project	8,711 nos. of LED luminaires have been installed by Smart Solutions
		Installed 257,716 nos. LED Luminaires by EESL in the state
		Installed 101,083 nos. LED Luminaires by NEESL in the state
3.	BEE-WB-SIDBI-GEF	Boost energy efficiency in MSME industrial clusters - 56 toe (0.65 MU) energy was saved in the state
4.	Building	427 Commercial buildings have been ECBC compliant in the State
5.	Unnat Jyoti by Affordable LED for All (UJALA) Scheme	Distributed 37770 nos. energy efficient fans in the state
		Distributed 52,270,570 LEDS in the state
		Distributed 170868 nos. energy efficient tube lights in the state
6.	Standard & Labelling	Energy saving through Standards & Labelling program

1.3. Opportunities and Challenges in Energy Transition in Odisha

1. Low to moderate growth in energy demand

Increasing penetration of energy efficiency in households and buildings will reduce power demand: There is a major thrust on introducing energy efficient appliances in households by EESL under its various programs - introduction of UJALA in Odisha resulting in savings of over 6799 MUs of power (EESL 2023). Odisha has the highest distribution of the LED bulbs under the UJALA programme. Subsequently there are plans to introduce energy efficient fans as well. Considering that

over 37% of State's power demand comes from the domestic segment, increased penetration of energy efficient appliances is expected to result in decrease in power demand. Additionally there is a clear thrust on implementation of Energy Conservation Building Code (ECBC) for commercial and residential sector buildings. ECBC was launched by the Bureau of Energy Efficiency and notified by the Odisha Government on March 2020, for its mandatory use in commercial buildings which is further reducing energy intensity in the buildings sector. From FY15-19, Odisha witnessed an energy saving of 2.119 MU under the Building Energy Efficiency Programme.

Industrial sector will also witness reduction in power demand due to penetration of low energy intensive manufacturing processes: Odisha has a high concentration of energy-intensive industries that include a mix of DCs as well as SMEs and performance of industries is monitored through PAT scheme. In Odisha, 67 energy intensive industries have been notified as Designated Consumers and have been given specific energy consumption reduction targets (for energy efficiency improvement) under the PAT scheme, resulting in an energy savings of 1774 MUs (~1.53 Mtoe) up to PAT cycle 3 (Activity Report Odisha 2022).This energy savings also translates into negating million tonnes of CO2 emissions. For SMEs, energy savings for FY2018-19 equal to 395 MUs and for FY2019-20, 651 MU (Bureau of Energy Efficiency 2020).

Energy efficiency through agriculture demand side management: Odisha has also been promoting energy efficiency through agriculture demand side management by reduction in overall power consumption, improving efficiencies of farm equipment, providing subsidies to install solar powered water pumps and drip irrigation systems (Soura Jalanidhi Scheme 2018). This is likely to reduce the energy intensity of agriculture pumping sector by carrying out efficiency up gradation of agricultural pump sets. Odisha SDA has replaced energy inefficient pumps with BEE star labelled pumps through Odisha Lift irrigation Corporation Ltd. An estimated energy saving of 15 MUs and capacity avoidance of 17 MW has been achieved by replacing 4316 nos. of lift irrigation pumps (Bureau of Energy Efficiency 2020).

2. Initiatives taken by the State in State for clean energy transition

Increasing electric mobility: The government of Odisha is bringing and implementing an EV policy (Government of Odisha 2021) to promote electric mobility within the state. The state is pushing for EV adoption as well as EV manufacturing with a combination of subsidies and tax exemptions in three segments, namely, consumer incentives, charging infrastructure incentives, industry incentives, etc. These initiatives indicate the intention of the state government to increase the penetration of EV across public and private transportation, leading to increased power demand and reducing demand for fossil fuels. In order to support such initiatives, adequate charging and storage infrastructure should also be scaled up accordingly.

Rapid industrialisation and upcoming developments: Odisha has been experiencing rapid industrialization in recent years, which has resulted in an increase in energy demand. To meet this demand, the state has been exploring renewable energy sources such as solar, wind, and hydropower. The Industrial Infrastructure Development Corporation (IDCO) has been allocated a budget of INR 600 crores to set up 23 new industrial parks within the next three years in Odisha. The government is also considering a proposal to provide incentives for industrial development in the backward regions and has also renewed its focus on development of ancillary industries to enhance employability and to accelerate economic development.

Power sector reforms: The government has been implementing various reforms in the power sector, such as the Ujwal DISCOM Assurance Yojana (UDAY) scheme, which aims to improve the financial health of power distribution companies. These reforms have created a conducive environment for the adoption of clean energy sources. A MoU has been signed by Industrial Promotion and Investment Corporation of Odisha (IPICOL) and Gas Authority of India Limited (GAIL) for cooperation in the

areas of renewable energy (solar/wind), green hydrogen for the production of eco-friendly fuels in Odisha.

Establishment of renewable energy parks: The government is also planning to set up renewable energy parks in the state. These parks will provide infrastructure such as transmission lines and substations to enable the development of renewable energy projects. The government is also offering various incentives to attract renewable energy developers to the state. Under the solar park scheme of MNRE, 1000 MW parks have been approved in Odisha covering 6 regions Balasore Keonjhar Deogarh, Boudh Kalahandi and Angul. The Government has approved 3 solar parks of cumulative capacity of 340 MW in Odisha at Village Landeihill Tehsil Jagannath Prasad 40 MW land based and 100 MW floating) and Rengali Reservoir 200 MW floating).

Promotion of e-cooking in Odisha: The government is promoting the use of electric induction cooktops in the state. These cooktops are more energy-efficient than traditional gas stoves and can help reduce carbon emissions. The government is providing subsidies to households to purchase electric induction cooktops along with distributing electric rice cookers to households in the state. These cookers are more energy-efficient than traditional gas stoves and can help reduce cooking time and fuel consumption. Several community kitchens has been set up in urban areas to promote the use of electric cooking. These kitchens are equipped with electric induction cooktops and other energy-efficient cooking appliances. Additionally, the government is offering incentives to restaurants and hotels that switch to electric cooking. These incentives include subsidies for the purchase of electric cooking appliances and electricity tariff subsidies.

Promotion of Solar pump irrigation: The government has been promoting the use of solar pump irrigation systems in the state. These systems use solar energy to power water pumps for irrigation. The aim is to reduce the dependence on grid-connected electricity for irrigation, which can be unreliable and expensive. Schemes like PM-KUSUM and Sourajalanidhi has resulted in the installation of over 1630 solar pumps by FY 2020.

Green hydrogen uptake: The state government is contemplating development of Green Hydrogen / Green Ammonia hubs to meet the demands of sectors like petrochemical / fertilizer / steel industry, long haul transport, city gas distribution as well as for export. They have already announced plans to set up a green hydrogen plant in the state. The proposed plant will use renewable energy sources such as solar and wind power to produce hydrogen. The state government is also exploring the possibility of setting up a green hydrogen hub in the state. The government is also likely to come up with a separate policy for development of an ecosystem for Green Hydrogen in the state clearly stating the incentives and concessions for Green Hydrogen projects.

3. Demand for cleaner energy production

Renewable mix in the grid would necessitate new skills to handle the power management: The Government of Odisha published the 'Odisha Renewable Energy Policy 2022' prioritizing goals, targets, and objectives in line with the 2030 Sustainable Development Goals. Supply side and demand side targets have been set to increase the share of renewable energy. The obligated entities including distribution companies (DISCOMs), captive users and open access consumers are mandated to achieve 43.3% RPO by FY2030. Odisha aims to increase its renewable energy capacity to 10,000 MW 2030[2]. Further, the following thrust areas have been identified for the state (projected based on MNRE targets):

[2] The 10 GW RE target calculated under the RE Policy 2022 does not cover the possibility of setting solar ground mounted projects on waste land.

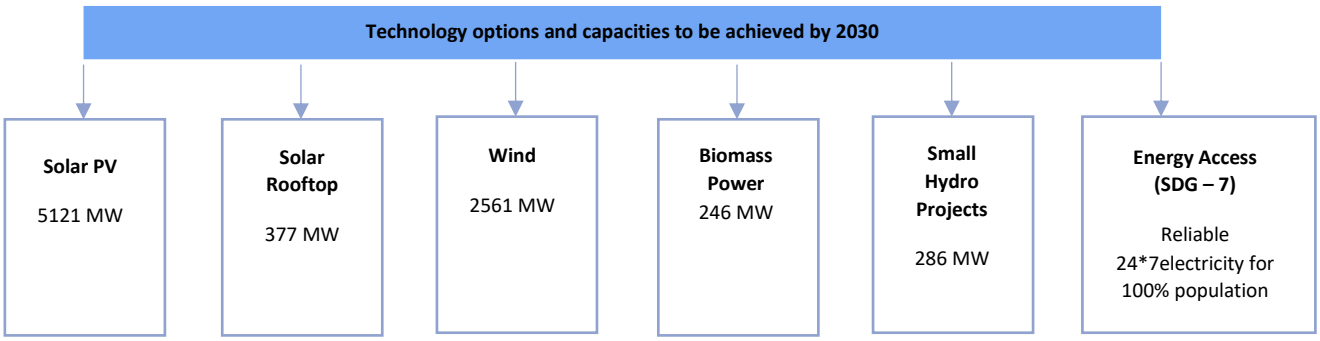


Figure 4: Energy supply targets for Odisha

Renewable energy being intermittent and infirm, would require adequate forecasting skill, scheduling capability, development of ancillary services and flexible thermal generation – which would necessitate development of skilled work force. Additionally, ancillary services represent new revenue opportunities for state utilities and other private players.

Special thrust on utilization of biomass in the state for power production and CBG generation: Odisha has been promoting the establishment of biomass-based power plants. In 2020, the government signed a memorandum of understanding with a private company to set up a 12 MW biomass-based power plant in the state. The government is also promoting the use of agricultural waste as a feedstock for biomass-based power plants. Moreover, Odisha has a high annual agricultural biomass surplus available (around 5 million tonnes) that can be used to produce 4000 GWh of energy every year. In addition, Odisha also has additional potential of CBG production from rice straw surplus as estimated to be 0.35 MMT of CBG every year. Under the scheme "National Biogas and Manure Management Program" family type biogas plants are being constructed in order to meet cooking lighting need of the households. Furthermore, around 500 CBG plants are expected to be commissioned in the state by 2023 under SATAT scheme. If enabling environment (regulatory, institutional, financial and technological) is created on time, extraction of these resources could bring a shift in the energy mix of the State and may open up the possibility of exporting energy in the region.

Besides the above-mentioned state specific drivers, the rapidly changing socio-economic condition of the country (World Economic Forum 2018) also necessitate the formulation of an Energy Plan in the state:

1. By middle of this century India will become a middle income country where more than 80% people will become middle class from 50% at current date.
2. Upward income mobility will drive growth across all consumption categories.
3. Country will become (including the state) most populous in the world and India will have 6 additional megacities which will have more than 10 million population.
4. India's population expected to surpass China's by 2030 and 2 out of every 5 citizens of the country will live in city.
5. India entered 37-year period of demographic dividend in 2018 where more than 77% Indian will be under 44 years of age. Employment generation will be the major challenge for the government for such a massive young and employable population.
6. India's internet economy is surging ahead with over 50% year-on-year growth. This expansion is likely to be fuelled by a rapidly increasing internet penetration rate, high-speed internet access, and increased online shopping and digital content consumption. Overall 1 billion people will be connected to internet in India by 2030 and a proportional population within the State as well.
7. New business models enabled by technology, will monetize and organize latent consumption opportunities in the country (including the state).
8. Consumer spending is envisaged to be more than doubled by 2030 in the country due to increasing middle class population indeed.

In the context of sustainable development of this burgeoning economy, certain immediate actions are required for the country and for the state as a whole to handle the future growth trends:

- Inclusion of rural sector in the overall economic growth model
- Managing the pollution and externalities caused due to increasing use of fossil fuels and other depletable natural resources.
- Managing solid wastes generated in the urban areas and promoting resource efficiency for consumption and production as well.
- Managing biomass waste generated in rural areas and exploring avenues for utilization of the same in power production and compressed gas generation.

2. Approach & Methodology of formulating the Energy Plan

Energy is an interdisciplinary area of the economy which has cross-linkages with other sectors of the economy, society and environment in such a way, that planning for energy in one particular area will require investigation in the possible cross sectoral impacts – a particular economic activity can be the consumer as well as producer of energy. Energy sector is also the primary contributor to the emission of pollutants in the atmosphere which ultimately has detrimental effect. Therefore, in the process of developing the state level energy plan and subsequent action plans it is important to follow an integrated approach of assessment.

In order to prepare the EP for the state of Odisha, a series of robust activities have been executed and following approach was developed viz. data collection and state energy database, data analysis and finally the development of state Energy Plan.

Data Collection and State Energy Database

An integrated methodology comprising of primary and secondary research was carried out at the energy supply and demand sectors at the state level. The primary data of past 10 years i.e., 2010 to 2020 was collected through various rounds of stakeholder meetings/ discussions held with state government departments in sector specific data collection framework. Whereas, in the absence of primary data, the gaps were collected through desk based secondary research such as government websites namely, Economic & Statistical Organisation, Government of Odisha, Central Electricity Authority (CEA), India Stat, Powermin etc., reports (Odisha activity reports, Infrastructure statistics of Odisha, Economic survey of Odisha, etc.), news articles, etc.

Post data collection, sectoral datasheets highlighting data received from primary sources and data collected from secondary sources was validated by respective stakeholder departments of Govt. of Odisha. Following this, state energy balance sheet was prepared which went through several rounds of data validation and was calibrated to the base year i.e., FY 2019-20. It was undertaken to ensure robustness of the data and hence opting a more streamlined baseline assessment for the state of Odisha. The following methodology/ approach for data collection and state energy database was adopted:

Figure 5: Methodology adopted for data collection and state energy database

Assessment and Analysis

Data analysis was undertaken by building an energy model using OSeMOSYS core engine which is a versatile, open-source, dynamic systems-optimization model. In order to build the model, the first step was to create a Reference Energy System (RES) for the base year, which maps the energy flow, starting from its primary level i.e. resource extraction to final energy level i.e. demand level utilization. The RES presents all inflow and outflow of energy, conversion efficiency, losses etc. for each and every energy commodity used in the system. After this, model simulation has been done to forecast energy supply and final energy demand (Agriculture, Building, Cooking, Industry and Transport) of the state up to 2040. The following figure shows the flow diagram of the entire methodology used for assessment and analysis.

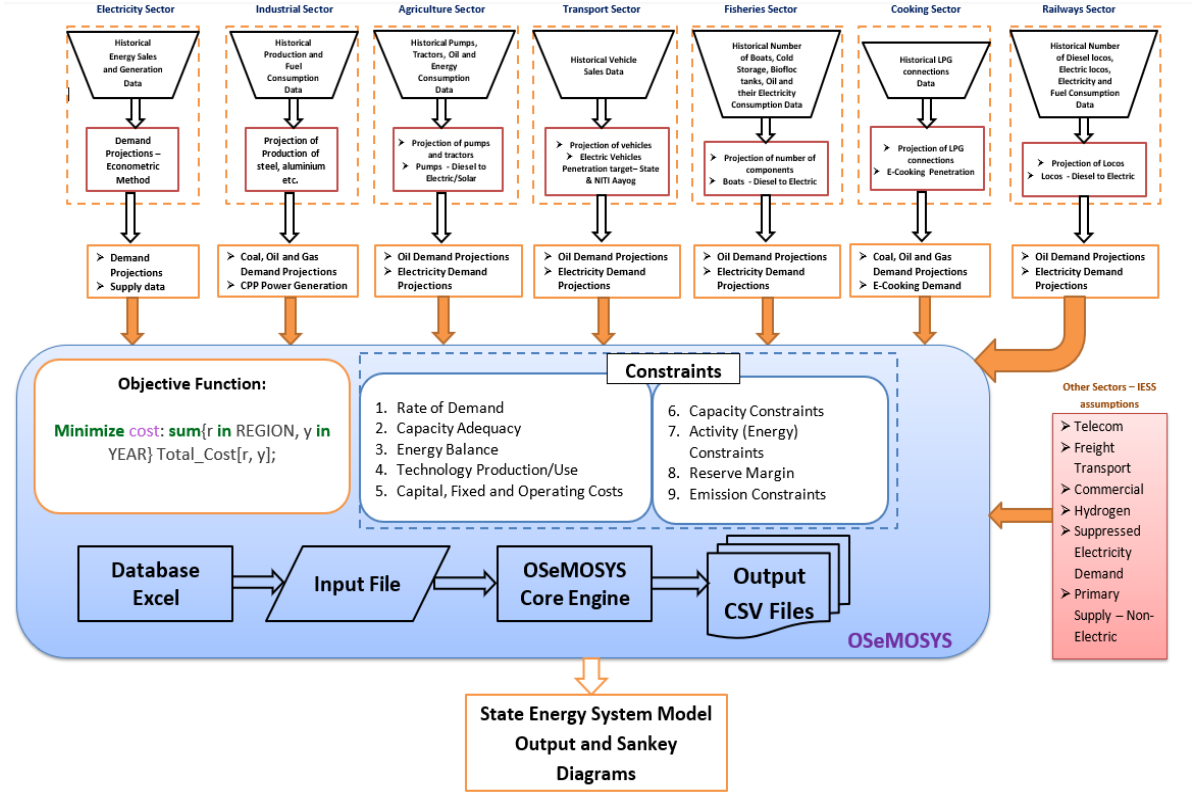


Figure 6: Methodology Flow Diagram

Developing State Energy Plan

After building the model, baseline or business as usual (BAU) scenario of optimal energy supply and demand situation of the state was run. Thereafter, potential future scenarios namely, state vision scenario, ambitious, aggressive and 100% decarbonisation scenarios based on targets and objectives in consultation with stakeholder departments were validated and developed. Based upon the model results, list of short-term, medium-term and long-term measures/ recommendations in each sector to be undertaken in the coming years was developed to achieve the objectives of the preferred future scenarios. Finally, these measures/ recommendations were converted into action plans at sectoral level and finally to the state level. The figure below shows the schematics of the integrated planning of energy sector for the state of Odisha:

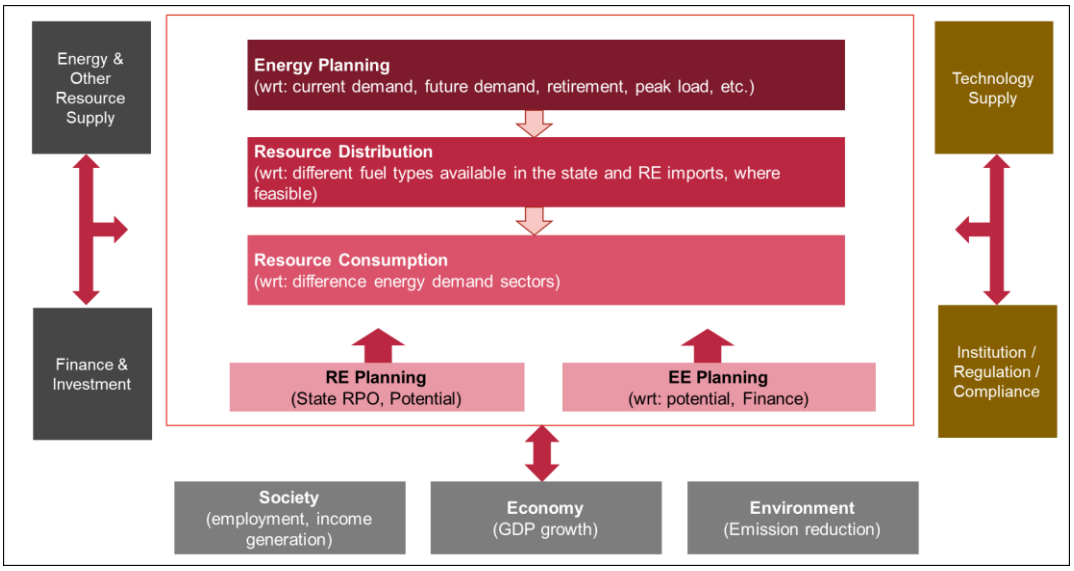


Figure 7: Schematics of State Energy Planning

The fundamental objective of energy planning is to link the energy sector to economy, society and environment through a causal chain relationship. Energy generation is linked to demand of energy which is further linked to economic growth and development. The following figure depicts the flow of information/ activities followed in the overall process of preparation of Energy Plan for the state of Odisha:

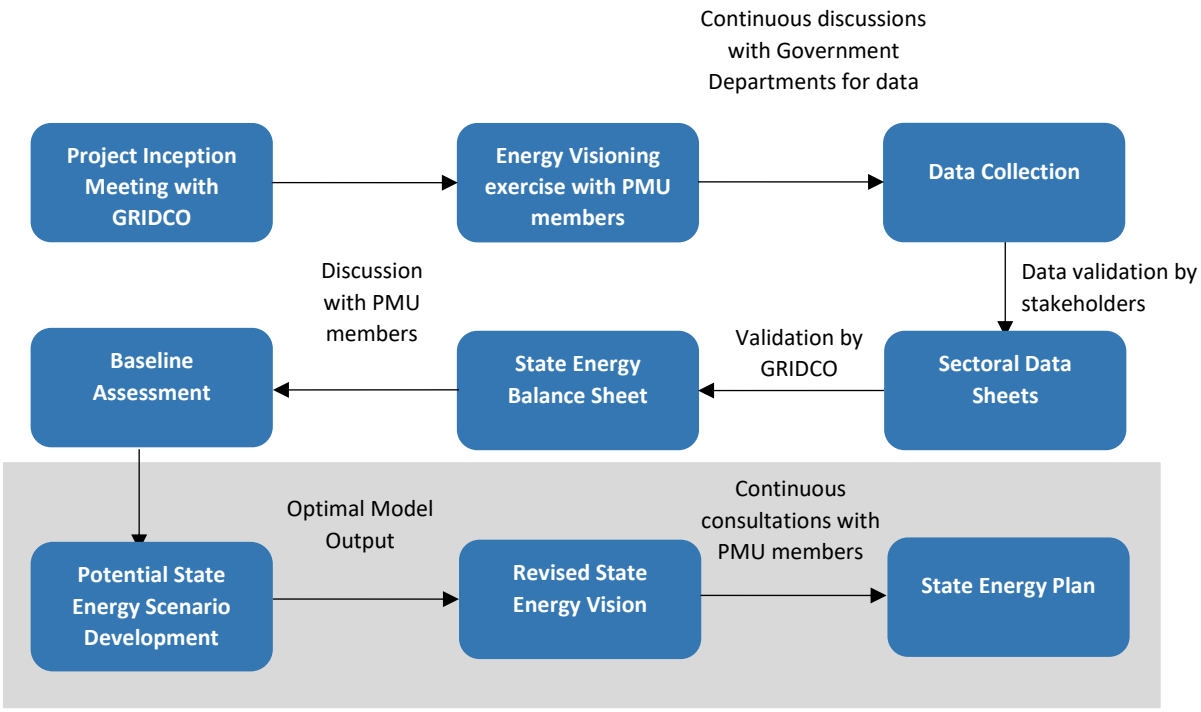


Figure 8: Flow of activities for developing State Energy Plan

2.1. State Energy Database Preparation

In order to develop the Energy Plan (EP), there is a need to build a robust state energy database that covers information regarding all existing and available energy through primary and secondary research. The primary purpose of state energy database is to comprehensively capture all major sectoral energy data and information on a historical basis. To complete this activity, the team cohesively worked with the Project Management Unit (PMU) formed at the State level that comprised of stakeholders from all

relevant line ministries and departments. The focus has been given on various parametric values which are state specific. The data has been researched and collected broadly into five categories:

i. At resource level (including import) like, coal, oil, natural gas or, biomass
ii. At primary energy level like crude oil at the refinery
iii. At secondary energy level like gasoline or diesel fuel at the refinery or, solar power at the power plant
iv. At final energy level like diesel fuel in the tank of a car or electricity at the socket
v. At useful energy level that satisfies some demand for energy services like heating, lighting or, transportation etc.

The departments' inputs are being sought on the following guiding questions on supply and demand side, upcoming strategies, targets, plans and priorities to be incorporated in the study:

Sectoral Policy Planning - focusing on learning from current policies, strategies being followed, updates on upcoming policies and targets set in the sector, suggestions/ recommendations for the action plan and integration of current policies (such as Odisha Renewable Energy Policy, 2022) with SAPCC and SDG targets
Low Carbon initiatives in the state of Odisha – programs/ low carbon schemes undertaken by the department; any new concept undertaken in the field along with investment plan for low carbon projects
Barriers and Support required – sectoral barriers viz. technical, financial, commercial etc. facing by the department and interventions/ support envisaged through EP/ EP
Case Studies implemented– any technology/ pilot study implemented, impact created (energy savings, GHG emission reductions) and challenges faced

For the purpose of the study, the entire energy sector of the state was divided into six demand sectors and one supply sector. While energy demand sectors included buildings, transport, industries, agriculture, cooking and fisheries, energy supply sectors comprised both primary (viz. coal, oil, and gas) and secondary sources (viz. electricity). Post data collection, sectoral data sheets were prepared for compiling sectoral information. In the process, data sensitization is being carried out and irrelevant and outlying data points are being sieved. The same is being validated with the relevant experts and concerned state government departments.

2.2. Odisha State Profile – A Snapshot

The Government of Odisha is continuously focusing on usage of renewable sources of energy in the state. As per Odisha Renewable Energy Policy 2022, state government aims to achieve a target of 10000 MW capacity additions of renewable energy by 2030 (including solar, wind, green hydrogen and biomass). Additionally, the state government has increased the Renewable Purchase Obligation (RPO) target from 11.5% in 2022 to 43.33% by 2029-30.

As per the analysis of historical trends, in terms of sectoral power consumption in the state, domestic sector had the highest power consumption in 2020-21 which stands at 43.6% followed by industry (35.23%) and commercial (10.9%) (Economic and Statistical Organisation, Government of Odisha 2022) and GRIDCO).

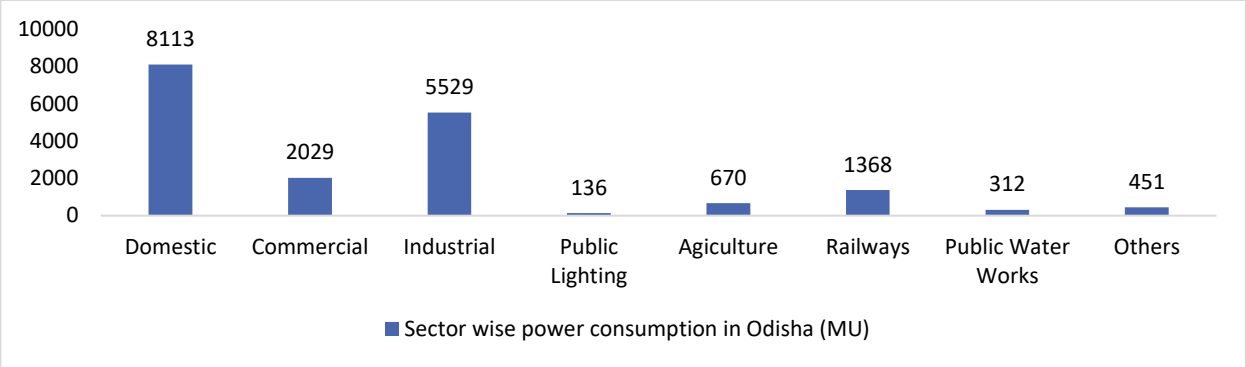


Figure 9: Sector wise Power Consumption in Odisha (MU) – 2021

Historic trends across sectors of Odisha

It was also observed across sectors, economic activities have been steadily growing that can be directly linked to the growth in electricity consumption. The CAGR recorded across various sectoral parameters have been outlined as under:

Table 6: Historic trends for various sectors of Odisha

Sector	Key data indicators	Year	CAGR (%)
Agriculture	Annual Electricity Consumption from the Grid (MU)	2011 to 2020	11%
	Share of Diesel operated Pump sets (%)	2012 to 2017	-2.2%
	Number of Electric operated Pump sets		13.6%
Industry	Annual Electricity Consumption (GWh)	2014 to 2020	15%
Building	Annual Electricity Consumption in Domestic sector	2010 to 2020	8.2%
	Annual Electricity Consumption in Commercial sector		15.5%
Transport	No. of Registered Vehicles (Nos.)	2010 to 2020	4-W PV: 14% 4-W CV: 9% Buses: 5.5% 2-W: 12% 3-W: 13%
Energy Supply	Total Installed Capacity	2011 to 2020	9%
	Capacity of Thermal Power Plants		15%
	Capacity of Renewable Energy		23%

In the cooking sector, the share of biomass in urban and rural households reduced to 13% and 57% in 2011. Overall shift towards usage of LPG has increased as 79% of households in Odisha had LPG connections and used LPG as their principal source of cooking fuel in FY21.

2.3. Key Sectoral Highlights/ Facts

All the data is available on the link

As per Odisha Economic Survey and data provided by GRIDCO, Odisha has the highest thermal captive capacity in the country. In terms of primary energy supply, in 2022, the share of coal stood at 58.2%, biomass at 1.48%, electricity at 10.1% including hydro (2%), thermal (4.2%), RE (1.2%) and ISGS (1.6%).

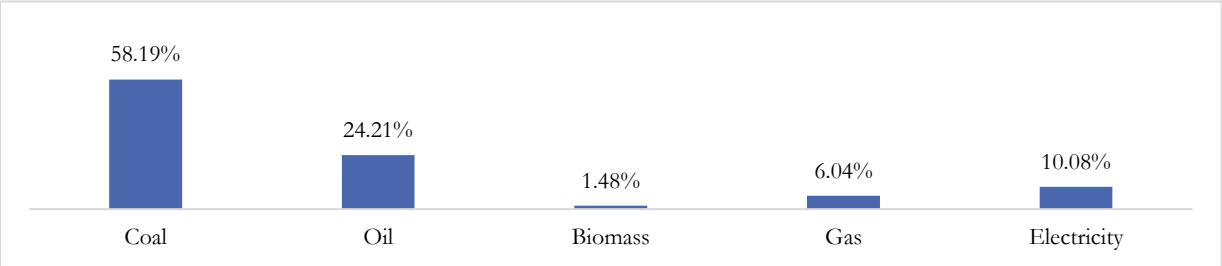


Figure 10: Primary energy supply in Odisha (%) in 2022

Electricity Sector

The historical trends of electricity supply sector highlights that the installed capacity from thermal power plants has increased from 1.62 GW in FY11 to 5.54 GW in FY20 whereas, the installed capacity from Hydro power plants has remained constant at 2.06 GW between the same period.

On the other hand, the installed capacity from solar power have increased enormously from 79 MW to 431 MW in 2022, mini/micro hydel projects stood at 100 MW in 2022 and biomass has contributed 50 MW in 2022 respectively.

Electricity Sector - Key Observations

- The installed capacity of thermal power plants has increased at a CAGR of 15% between FY 11 to FY20. This indicates continuous reliance on thermal power for meeting the electricity needs of the state
- The installed capacity of RES has increased at CAGR of 23% (from FY 11 to FY20). This high growth in RE is encouraging but it is largely on the back of small base (0.08 GW to 0.51 GW).
- The installed capacity of solar power has increased at a CAGR of 40.4% since 2017 indicating a positive sign towards cleaner energy transition

The coal consumption in power sector has increased at a CAGR of 6.67% (from FY12 to FY20) which indicates high reliance on coal for power generation. This indicates continuous reliance on thermal power for meeting the electricity needs of the state. The installed renewable power capacity has more than doubled since 2018 and with falling prices of renewable energy and government focus on increasing RE penetration, it is expected to see significant jump in the years to come. The below figure highlights the trend of installed capacity and its break in the state between FY 2011 to FY 2020:

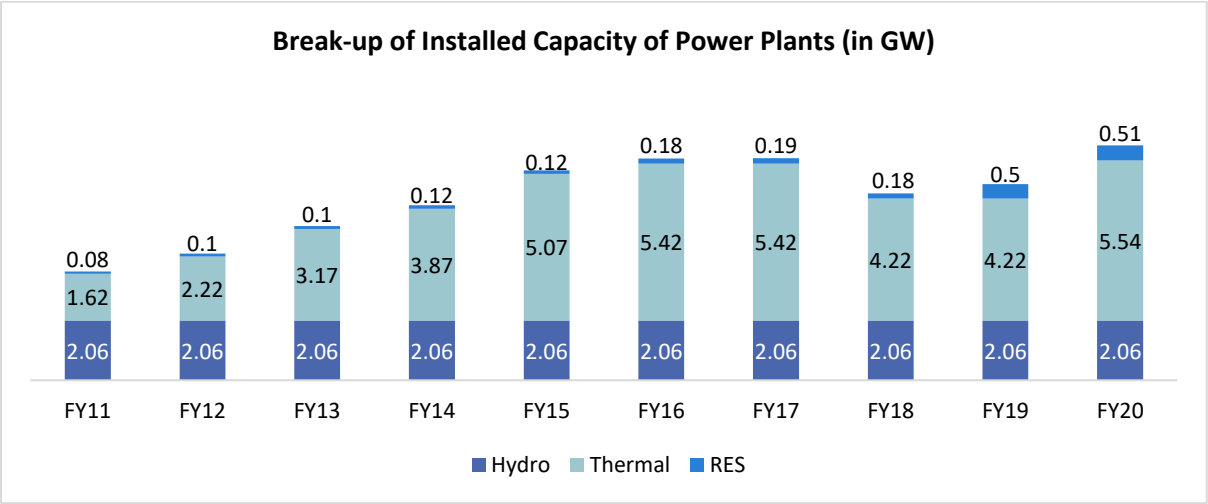


Figure 11: Installed capacity trend in Odisha

Consumption of Petroleum Products

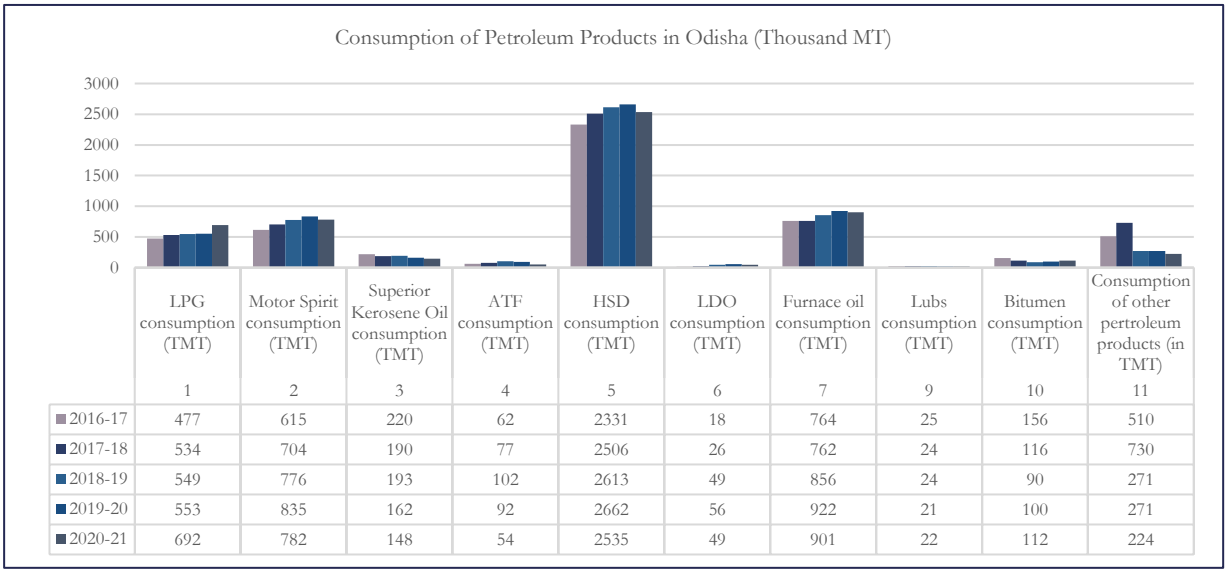
It is observed that the consumption of petroleum products in Odisha has increased from 81.2 TMT in FY 2012 to 143.7 TMT in FY 2021 and shows an upward trend (MoPNG 2021). On the other hand, consumption of LPG has also increased from 213 TMT in FY 2012 to 692 TMT having 88.8 lakh connections in 2021.

Petroleum Products - Key Observations

- Consumption of petrol, high speed diesel oil and LPG has increased at a CAGR of 10%, 4% and 15.9% between FY 2013 and FY 2021.
- Consumption of industrial kerosene oil and lubs has decreased at a CAGR of 8.8%, and 0.5% between FY 2013 and FY 2021.

As far as consumption of light diesel oil is concerned, it was 30 TMT in FY 2013 and reduced to 18 TMT in FY 2017 and again increased to 49 TMT in FY 2021. Odisha has one of the highest kerosene consumptions share in India (8.3%) (MoPNG 2021). The below figure highlights the consumption pattern of petroleum products in the state:

Figure 12: Consumption of Petroleum products in Odisha (Thousand MT) (Source: MoPNG)



	LPG consumption (TMT)	Motor Spirit consumption (TMT)	Superior Kerosene Oil consumption (TMT)	ATF consumption (TMT)	HSD consumption (TMT)	LDO consumption (TMT)	Furnace oil consumption (TMT)	Lubs consumption (TMT)	Bitumen consumption (TMT)	Consumption of other pertroleum products (in TMT)
	1	2	3	4	5	6	7	9	10	11
2016-17	477	615	220	62	2331	18	764	25	156	510
2017-18	534	704	190	77	2506	26	762	24	116	730
2018-19	549	776	193	102	2613	49	856	24	90	271
2019-20	553	835	162	92	2662	56	922	21	100	271
2020-21	692	782	148	54	2535	49	901	22	112	224

Agriculture

Odisha is a well irrigated state with majority of the cropped area under irrigation. The main sources of energy consumption in the sector are agricultural machinery/ equipment, net irrigated, and cropped area, and pump sets in the state of Odisha. The total electricity consumption in the agriculture sector has shown a gradual increase to reach around 4% of total electricity sales in Odisha (736 MU) in FY2021 compared to 1.14% in FY11. Further, the farm power availability also increased from 1.12 kWh / ha in FY11 to around 1.86 kWh / ha in FY 20. (Source: Agriculture Department of Odisha and GRIDCO).

Agriculture - Key Observations

- Odisha has a farm power availability (1.86 kW/ Ha) in India (1.5 kW/ Ha).
- The share of electric pumps has increased at a CAGR of 14% between 2012 and 2017.
- The penetration of electric pumps has increased the energy consumption at a CAGR of 17.9% between FY 2011 and FY 2020.
- Solarization of agricultural pumps has accelerated in the state due to the implementation of PM-KUSUM.
- Overall, state of Odisha had 9,551 solar pumps installed as of FY20
- 3.02-4.03 Lakh tonnes of CBG can be produced every year from rice straw in Odisha assuming entire rice straw surplus is being used for CBG production.
- The surplus biomass availability in Odisha ranges between 4.5–5.5 MMT per annum which can produce 3,383 – 4,135 GWh of power every year

The share of diesel pumps is highest contributing to 62.34% of the total base of the pump set installed in the state followed by 32.5% of electric pumps and 5.16% of solar pumps. The penetration of diesel pumps has reduced from 69.64% in FY12 to 62.34% in FY17 and there has been a gradual shift in the fuel mix for pumps from diesel to electric. The penetration of solar pumps has increased to 5.16% in FY17 from NIL in FY12.

Further, the solarization of agriculture pumps is being accelerated in the state under the implementation of PM-KUSUM scheme of the Government of India. The state has a target of installing 5,740 number solar pumps (stand-alone off-grid) as cumulative additional capacity between FY20 to FY23, out of which 997 standalone solar pumps have been installed so far. Overall, state of Odisha had 9,551 solar pumps installed as of FY20.

The below figures highlights the annual total electricity consumption (MUs) along with the Share of pumps used in agriculture sector:

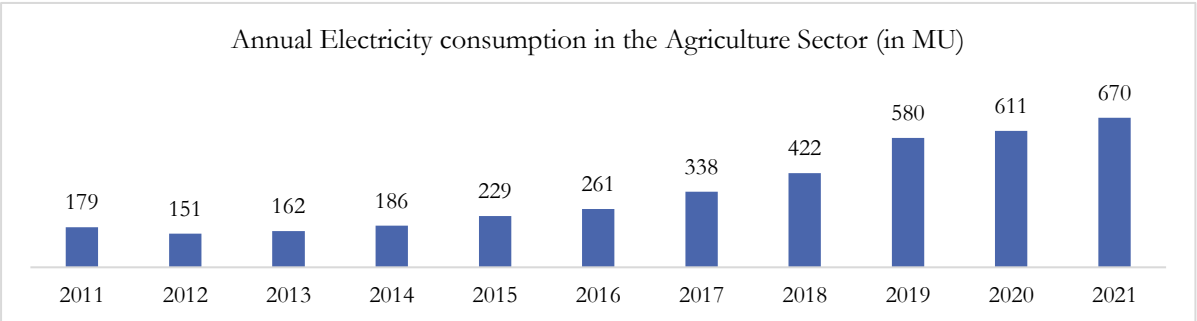


Figure 13: Annual electricity consumption (MUs) of agriculture sector in Odisha

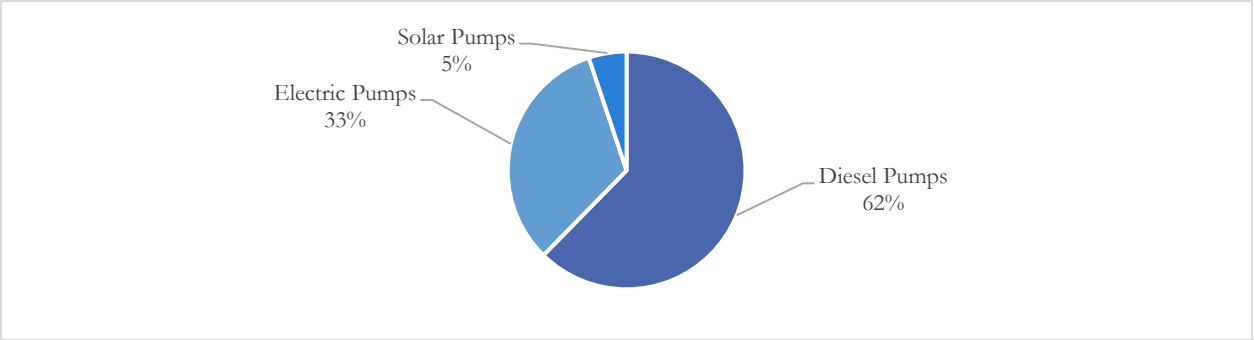


Figure 14: Share of pumps used in agriculture sector of Odisha (FY17)

Agriculture Sector as the Potential Supplier of Energy

On the cultivation side, the major agricultural (principal) crops grown in Odisha include rice, maize, moong, tur, groundnut, sugarcane, and cotton.

- Odisha had a total crop production of 15.24 MMT in FY21 and as such, available crop residue of 25.51 MMT.
    - On average, considering the crop residue available in the state, the annual agricultural biomass surplus available in Odisha ranges between 4.5–5.5 million tonnes.
    - Assuming the entire available surplus is utilized for power production, surplus biomass ranging between 4.5–5.5 MMT per annum will be able to produce 3,383–4,135 GWh of power every year.
    - This would mean possible capacity installation of 600-740 MW of biomass power plants in the state (calculation is provided in Appendix 2).
- Factoring in the CBG generation potential using agri-waste in Odisha under the SATAT scheme, multiple CBG plants can be installed in Odisha.
    - Considering an average of 3-4 MMT of rice straw available for CBG production in Odisha each year, 0.294-0.392 MMT of CBG can be produced every year assuming the entire rice straw surplus is being used for CBG production.

However, to exploit the potential of biomass power plants, CBG generation and biomass densification by converting raw biomass into biomass pellets and briquettes, appropriate infrastructure is required to be developed in the state to extract the maximise energy potential.

Fisheries

Odisha is endowed with the rich potential of inland, brackish water, and marine fishery resources. The State has 6.88 lakh hectares (ha) of freshwater resources, 4.18 lakh ha of brackish water resources, and 480 km of coastline for fisheries development. The overall fishery sector has grown at a CAGR of 10.14% between 2011- 12 and 2021-22, with fishing & aquaculture

Fisheries - Key Observations

- In Odisha, out of the total fish production, freshwater fish constitutes 66%, brackish water 14%, and marine fish 20% for the year 2020-21
- It is observed that the fishery sector has grown at a CAGR of 10.14% between 2011- 12 and 2021-22, with fishing & aquaculture contributing 2.43% to GSVA in FY22
- Odisha had around 1741 motorized mechanical fishing vessels, and 12,246 motorized non-mechanical fishing vessels all of which operate on diesel motors
- Penetration of solar power and energy efficiency in fish harvesting processes by ensuring a shift of fuel for fishing vessels from diesel to solar and electricity will help maximise resource use while lowering the expenses associated with fuel usage

contributing 2.43% to GSVA in FY22 (Economic and Statistical Organisation, Government of Odisha 2022).

The primary source of energy consumption in the fisheries sector is diesel, being consumed by fishing vessels, trawlers, brackish and freshwater farms, and hatcheries. In FY20, Odisha had around 1741 motorized mechanical fishing vessels, and 12,246 motorized non-mechanical fishing vessels all of which operate on diesel motors. The annual diesel consumption of motorized fishing vessels has increased with a CAGR of 6.8% from FY18 to FY21 and the annual electricity consumption in cold storage or processing plants has increased to 60.7 MUs in FY21.

The following figures shows the significant rise in the total fish production in Odisha as of FY21 along with the penetration of different types of fishing vessels in Odisha:

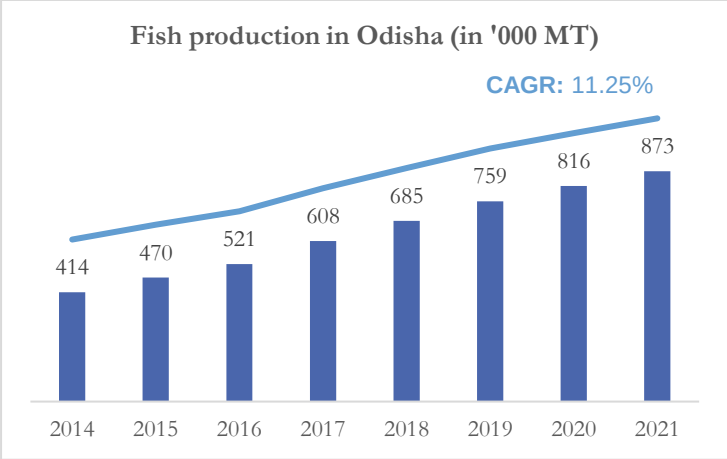


Figure 15: Annual fish production in Odisha (TMT)

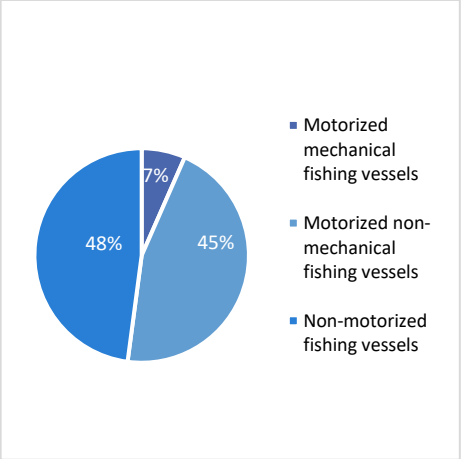


Figure 16: Penetration of fishing vessels - Odisha

Building

Buildings constitute a big proportion of electricity consumption in the state. Within the building sector (including govt. buildings), domestic sector forms the bulk consumer and has been growing consistently. The electricity demand is rising sharply because of rapidly increasing use of electrical energy because of urbanization, increasing affluence and intensive rural electrification programme.

The domestic sector accounted for 37% and commercial sector with 12% of the total power consumption in the state in 2020. The commercial sector constitutes government & private establishments, hospitals, hotels, restaurants, educational institutions, malls etc.

Building - Key Observations

- It is observed that the domestic sector is the largest consumer of electricity in Odisha accounting for about 37.41% (7327 MU) of total consumption.
- The share of energy efficient appliances and solar rooftop installation is gradually increasing.
- The cumulative capacity of 7.71 MW solar rooftop plants has been installed in the state of Odisha.
- The connected load in commercial and domestic sectors has grown at a CAGR of 6.6% and 8.8% respectively between 2015 and 2020.

The total power consumption in domestic and commercial sector has grown from 3533 MU in FY 2011 to 8113 MU in FY 2020 and 1113 MW in FY 2011 to 2029 MU in FY 2021 at a CAGR of 8.7% and 6.2% respectively.

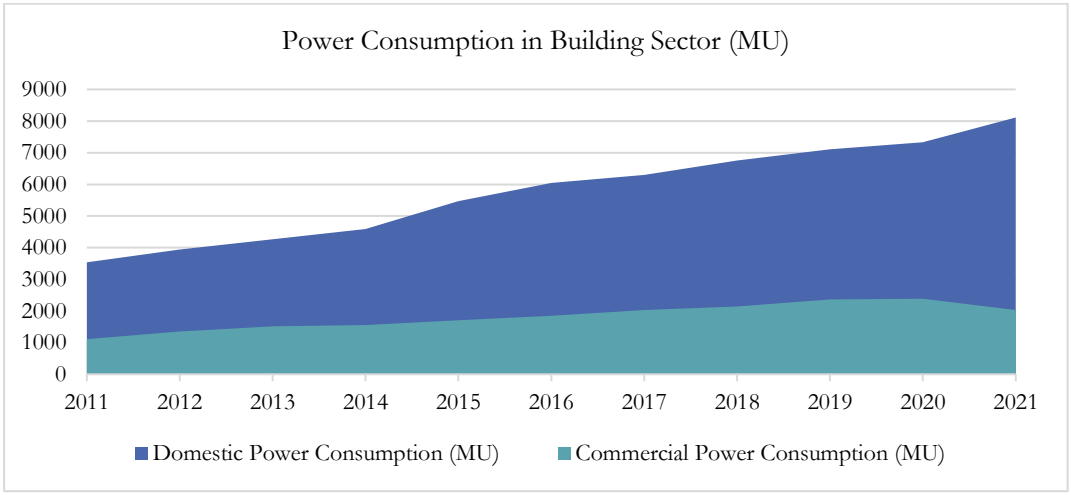


Figure 17: Power Consumption in Domestic and Commercial Sector (MU) (Sources: Economic Survey Report Odisha (CESU, NESCO, SOUTHCO and WESCO)

Cooking

The main fuels used in the sector are solid hydrocarbons (i.e., coal and biomass), liquid hydrocarbons (i.e., LPG and kerosene), gaseous hydrocarbons (i.e. PNG and biogas) and electricity.

Cooking

- Share of biomass in urban and rural households accounts for 19% and 77% in 2001, which reduced to 13% and 57% in 2011.
- There is a growing importance of LPG in the consumption of urban and rural households. Near about 79% of households had LPG connections in FY21
- Domestic PNG connections have grown at a CAGR of 575% in Odisha between FY18 and FY21.

The growing importance of LPG which is reflected in its consumption pattern in urban and rural households i.e., an increase in the number of LPG connections from 4.49 million in 2017 to 8.88 million in 2021. The below figures highlights penetration of type of fuel used in urban and rural households in the state:

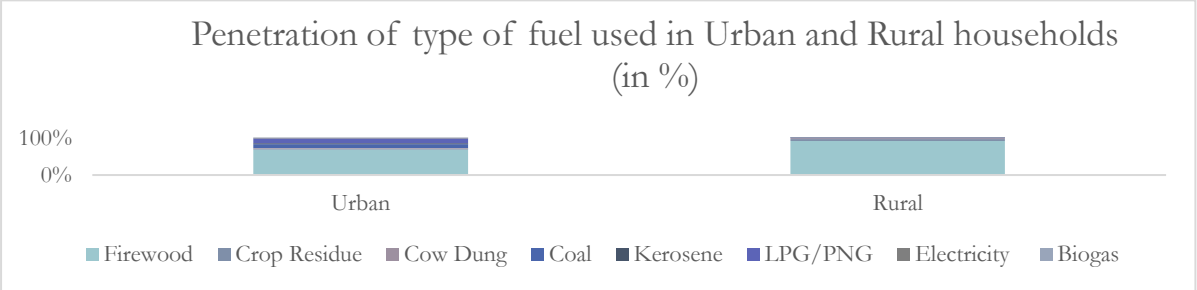


Figure 18: Penetration of type of fuel used in Urban and Rural households of Odisha (%) (Source: Odisha Census Report)

Odisha had also launched Improved Cookstove Programme under which 10,754 schools have been provided with improved cook-stoves for cooking mid-day meals and 7,256 portable chullahs have been supplied to DFOs and Range officers for distribution to households in forest/forest fringe villages till 2018-19.

Industry

Industry is one of the key drivers of Odisha's economy. The average contribution of the industrial sector to State's GDP has remained around 40% for the last 7 years compared to 30% for India which shows

the heavy reliance of Odisha on the industrial sector. The large share of industries in Odisha's GDP comes from it being a state rich with reserves of minerals and metals such as coal, bauxite, iron ore, manganese, nickel, chromite etc.

Industry - Key Observations

- Odisha's industrial GVA has nearly doubled over the last 8 years with CAGR of 7%.
- The electricity consumption of industries has grown at 12.5% CAGR from FY 15 to FY 20
- The electricity consumption from grid is only about 33% of total electricity consumption of industries
- The state has ~12 GW of CGP capacity of which around 98% of coal/diesel/gas based
- In FY 20, the industries in the state consumed around 19 million tonnes of domestic coal in processes (highest in the country).
- The brass and sponge iron industries have more than 95% share of coal/charcoal in the fuel mix.

Industries consume electricity from grid as well as through the captive generation plants (CGP). In case of Odisha, a large share of electricity consumption comes through CGPs. In FY 2020, while industrial consumption through grid was 6,898 MU, the consumption through CGPs was 54,192 MU. The state has ~12 GW of CGP capacity of which around 98% of coal/diesel/gas based.

Therefore, the captive segment will play a major role in the decarbonization of the State. It is imperative to put in place policies and support mechanisms to encourage industries to shift to cleaner fuels. This needs to be done in such a manner that it does not add to the operating cost for these industries so that their competitiveness is not impacted. This is especially important for aluminium, iron and steel industries as these are important industries for the country's growth and also a major export item as well. The electricity consumption pattern in the industrial sector is shown in the figure below:

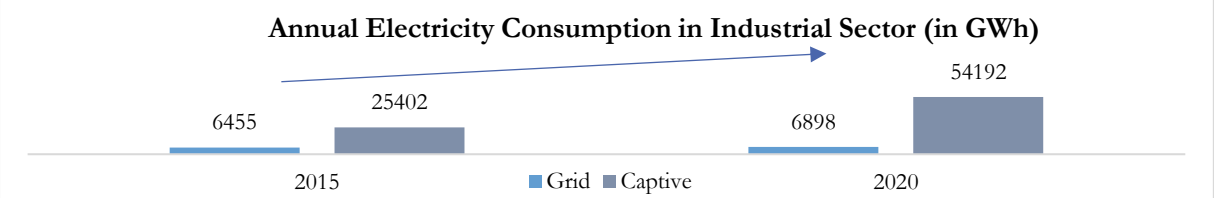


Figure 19: Annual Electricity Consumption (GWh) in industries

While 36% of the total grid electricity is being consumed by the industry sector, majority of the industrial energy demand is being provided by fuels like coal, oil, gas, biomass etc. In 2020, coal caters to ~92% of the industrial energy requirement, followed by petroleum oil based fuels with more than 5% and natural gas with 3%. 0.5% of the total industrial energy demand is provided by using solar energy (captive power).

Transport

The use of passenger transport is considerably higher in the state of Odisha. The transport sector grew at a CAGR of 6.74% between FY13 to

Transport - Key Observations

- From FY 17 to FY 20, the average annual sales of vehicles in Odisha has been around 8.5 lakhs with 2 wheelers comprise nearly 82% of new vehicle sales.
- The annual demand for trucks surged at a CAGR of 19.47% between FY14 and FY20 whereas demand for two wheelers and four wheelers grew at a CAGR of 9%.
- In FY 22, petrol vehicles had the highest share amongst the total registered vehicles in Odisha amounting to (301816) in number followed by Diesel vehicles (34855) and EVs.
- In FY 22, the share of EV was around 10% in total sales which indicates good progress.
- The consumption of petrol and high speed diesel in the state in FY 20 was 835,000 tonnes and 26,62,000 tonnes respectively.

FY20 with road transport contributing the largest share of GSVA in transport services (Economic and Statistical Organisation, Government of Odisha 2022).

The total number of registered vehicles has witnessed 11.6% CAGR growth rate between FY14 to FY20 in the state of Odisha with cars and taxis growing at a CAGR of 8% each and 2-W, buses and LGV-passenger growing at a CAGR of 9%, 14% and 15% between FY 15 to FY 20 ((MoRTH) 2022).

HSD is the most consumed petroleum product in the transportation sector followed by MS and ATF respectively. This indicates transport of goods is major source of petroleum consumption since most cargo transports are diesel vehicles. In FY20, HSD accounted for 74% of petroleum consumption followed by MS at 23% and ATF at 3% (Transport Department, Odisha).

The share of no. of vehicles as per fuel type (petrol and diesel) in transport- passenger and freight category across the state is presented below:

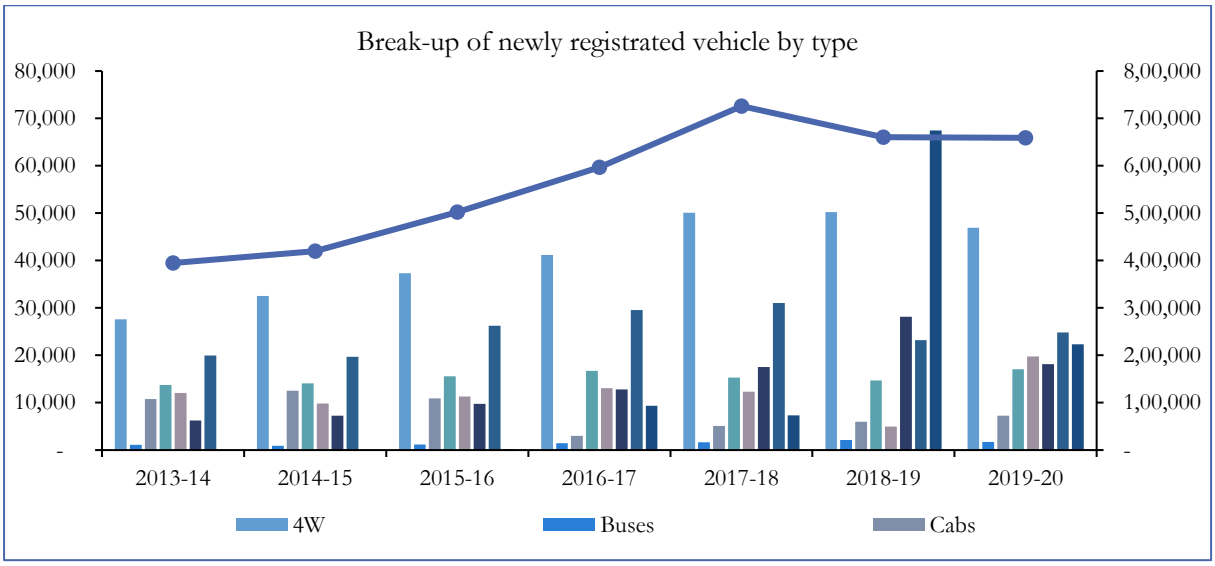


Figure 20: Newly Registered vehicles by type in Odisha

2.4. Energy Balance Sheet for Odisha

To model an energy system for Odisha, the first step is to prepare an energy balance sheet detailing the current status of energy supply and demand to calibrate the model. The energy balance sheet provides information on the supply and demand gap and subsequent energy required to balance the system. The energy balance sheet contains three sections:

1) Primary energy supply
2) Energy Transformation
3) Final energy consumption and non-energy use

The whole exercise of balancing the model is attributed to satisfy the assumption that the entire energy supply chain is well accounted for. The data gaps are shown as statistical differences. Ideally, the statistical differences should be zero, which indicates full accountability of energy data gathered by the state. This exercise of building an energy balance sheet also validates that the energy data collected from various sources are consistent and correct. The energy balance sheet contains data on the supply and consumption for each energy commodity (natural gas, crude oil, hard coal, and renewable energy).

Methodology for the Development of Energy Balance Sheet

Primary and secondary data collection has been the pivotal process for preparing the energy balance sheet for Odisha. While preference was given to primary data collection, in the absence of such information the data gaps were suitably supplemented using reliable secondary sources that were used as proxies. For primary data collection, the

department/sector-specific data collection framework in the form of questionnaires was created for collecting and compiling both conventional and non-conventional data for FY 2020.

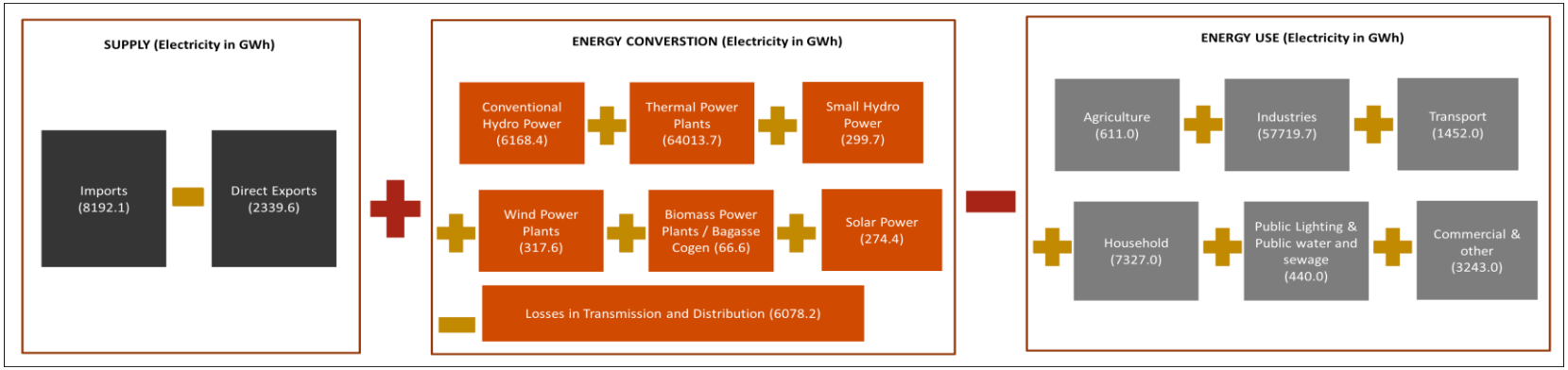
In the absence of primary data, the sector/department-specific secondary data was collected through desk-based research. Key sources referred to included government websites namely, gridco.co.in, desorissa.nic.in, oredaodisha.com, etc., reports (Odisha Economic Survey, Ministry of Statistics and Programme Implementation (MoSPI) Annual Survey of Industries, Ministry of Petroleum and Natural Gas (MoPNG) statistical report, Ministry of Road Transport and Highways (MoRTH) Road Transport Yearbook, etc.), journals and reliable news articles, etc. A detailed description of the categorization in the energy balance is further provided below. This form of the Energy Balance Sheet can be referred to by individual departments dealing with respective fuel sources. The energy commodity balance sheet for FY 2019-20 for the state of Odisha is provided below. To mitigate the knee-jerk reaction in energy supply and demand caused by the COVID-19 pandemic and for a more accurate representation of the energy supply and demand sectors, FY2019-20 has been chosen as the base year for the preparation of the energy balance sheet for Odisha.

In the table below energy supply, energy conversion (from primary supply to useful supply) and finally energy use in energy demand sectors. Fuel mix in energy supply consists of:

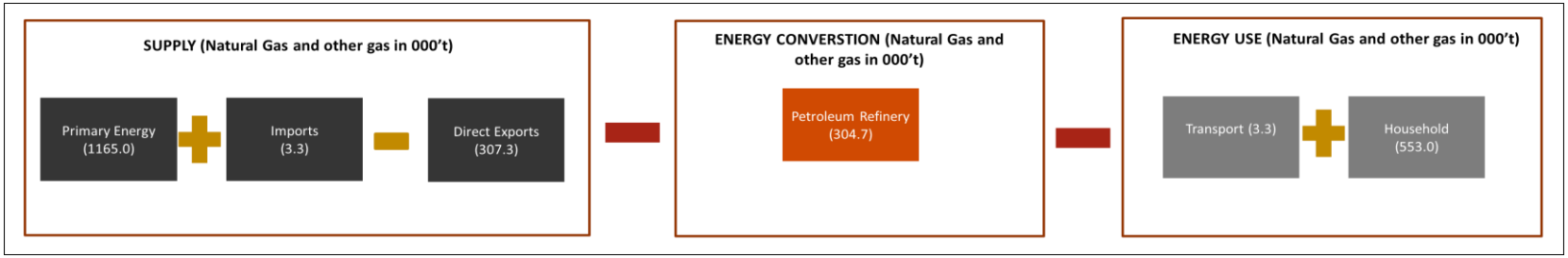
- Electricity
- Natural gas
- Oil
- Coal
- Biomass.

These sources of energy are either utilized as an input for electricity generation or directly utilized in the energy demand sectors. As mentioned above, the basis of energy balance of the State is its commodity balance. This primarily aids in understanding the share of state's energy purchased from external sources as well as the commodity wise consumption by different sectors. The graphical representation of the energy balance for Odisha for FY 2019-20 has been presented below.

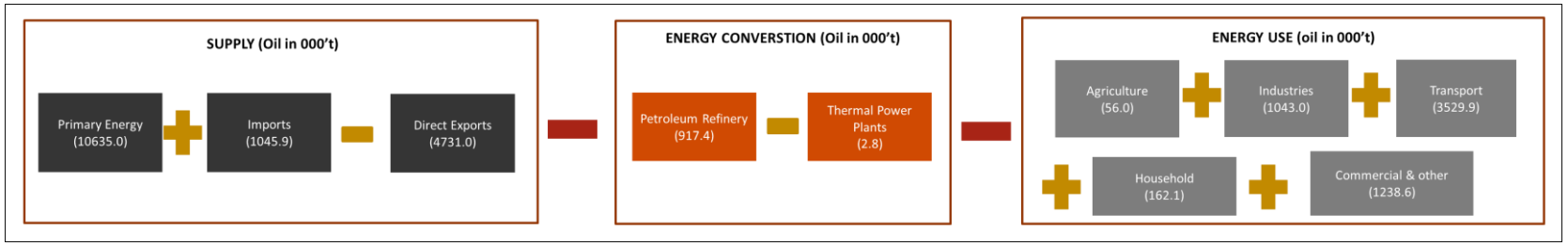
Electricity



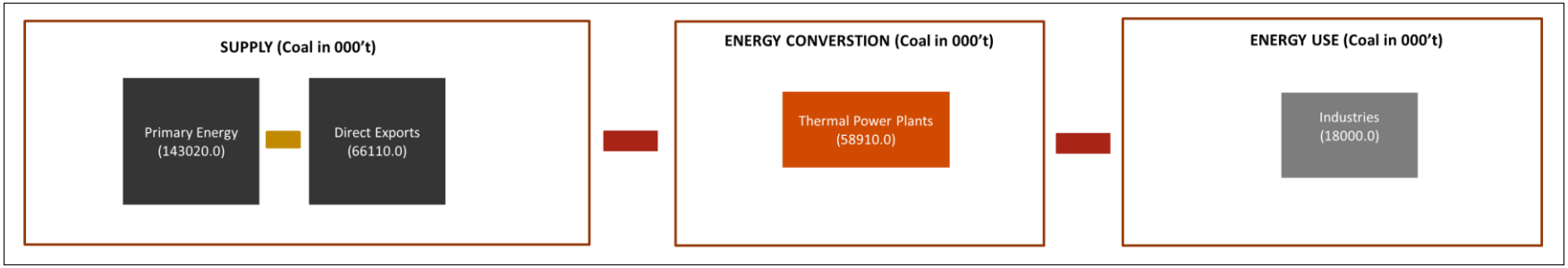
Natural Gas and other gases



Oil



Coal



Biomass

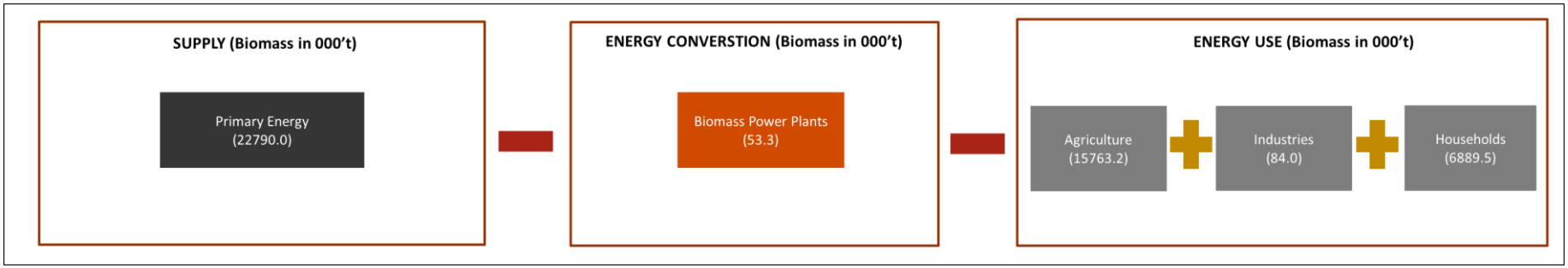


Table 7: Odisha Energy Balance 2019-2020 (in original units)

Odisha Energy Balance 2019-20 (in original units)						
Sr.		**Electricity (GWh)**	**Natural Gas and other gas (000't)**	**Oil (000't)**	**Coal (000't)**	**Biomass (000't)**
A	**Supply**					
1	Primary Energy		1165.0	10635.0	143020.0	22790.0
2	Imports	8192.1	3.3	1045.9		
3	Direct Exports	2339.6	307.3	4731.0	66110.0	
4	**Total Energy Supply**	**5852.5**	**861.0**	**6949.9**	**76910.0**	**22790.0**
B	**Energy Conversion**					
1	Petroleum Refinery		304.7	917.4		
2	Conventional Hydro Power	6168.4				
3	Thermal Power Plants	64013.7		2.8	58910.0	
4	Small Hydro Power	299.7				
5	Wind Power Plants	317.6				
6	Biomass Power Plants / Bagasse Cogen	66.6				53.3
7	Solar Power	274.4				
8	Less : Losses in Transmission and Distribution	6078.2				
9	**Total Energy Conversion**	**65062.2**	**304.7**	**920.2**	**58910.0**	**53.3**
C	**Use**					
1	Agriculture	611.0		56.0		15763.2
2	Industries	57719.7		1043.0	18000.0	84.0
3	Transport	1452.0	3.3	3529.9		
4	Household	7327.0	553.0	162.1		6889.5
5	Public Lighting & Public water and sewage	440.0				
6	Commercial and Other	3243.0		1238.6		
7	**Total Energy Use**	**70792.7**	**556.3**	**6029.6**	**18000.0**	**22736.7**
D	**Balance**	**122**	**0.0**	**0.0**	**0.0**	**0.0**

Converting commodity balance to energy balance

In the energy balance sheet, energy supply, consumption, and losses are balanced in energy units like kWh, toe, etc. Each commodity in the energy system has certain energy content which is denoted by the gross calorific value of the commodity (represented in Gcal/000'tonnes).

Table 8: Calorific values and conversions for different fuel types

Calorific Values			Conversions		
PNG	11500	Gcal/000'tonne	1 GWh =	0.08604	Thousand toe
Oil Products	10000	Gcal/000'tonne	1 Gcal =	1.00E-04	Thousand toe
Coal	2772.6	Gcal/000'tonne			
Biomass	3100	Gcal/000'tonne			

In the energy calculation, each commodity (in tonnes or kilograms) is multiplied by gross calorific value to get the equivalent energy content available in the commodity. This is useful for the analysis of energy production, consumption, efficiency measurement of the conversion processes, and energy modelling for optimal supply mix. The energy balance sheet is shown below.

Table 9: Odisha Energy Balance 2019-20 (in thousand toe)

Odisha Energy Balance 2019-20 (in thousand toe)					
	Electricity	**Natural Gas**	**Oil**	**Coal**	**Biomass**
Supply					
Primary Energy	0.00		10635.0	39616.5	7064.9
Imports	704.40	3.8	1045.9	0.0	0.0
Direct Exports	201.17	353.4	4731.0	18312.5	0.0
Total Energy Supply	**503.22**	**990.1**	**6949.9**	**21304.1**	**7064.9**
Energy Conversion					
Petroleum Refinery	0.00	319.9	917.4	0.0	0.0
Conventional Hydro Power	530.38	0.0	0.0	0.0	0.0
Thermal Power Plants	5504.18	0.0	2.8	16318.1	0.0
Small Hydro Power	25.76	0.0	0.0	0.0	0.0
Wind Power Plants	27.31	0.0	0.0	0.0	0.0
Biomass Power Plants / Bagasse Cogen	5.72	0.0	0.0	0.0	16.5
Solar Power	23.59	0.0	0.0	0.0	0.0
Losses in Transport and Distribution	522.63	0.0	0.0	0.0	0.0
Total Energy Conversion	**5594.34**	**350.4**	**920.2**	**16318.1**	**16.5**
Use					
Agriculture	52.53	0.0	56.0	0.0	4886.6
Industries	4963.00	350.4	1043.0	4986.0	26.0
Transport	124.85	3.8	3529.9	0.0	0.0
Household	630.00	636.0	162.1	0.0	2135.7
Public Lighting & Public water and sewage	37.83	0.0	0.0	0.0	0.0
Commercial and Other	278.84	0.0	1238.6	0.0	0.0
Total Energy Use	**6087.07**	**639.7**	**6029.6**	**4986.0**	**7048.4**
Balance	**10.48**	**0.0**	**0.0**	**0.0**	**0.0**

2.5. Reference Energy System of the Odisha

The Reference Energy System (RES) represents the entire energy system of the state through a schematic line diagram which shall depict the flow of energy across processes undertaken within the system to convert one form of energy to another. Since each energy conversion process involves a dedicated technology, RES provides the total set of available energy conversion technologies involved in resource extraction, transformation, transport, distribution as well as end-use. The final stratum of the RES provides information on a key metric required for developing an optimized model of energy system i.e., useful energy demand.

Since there are few conversion technologies which convert resources directly into useful energy, the RES of the state works on the mapping of 5 level conversion namely:

i. At Resource (r) level (including import) like coal, oil, natural gas or, biomass
ii. At Primary (a) energy level like crude oil at the refinery
iii. At Secondary (x) energy level like gasoline or diesel fuel at the refinery or, solar power at the power plant
iv. At Final (f) energy level like diesel fuel in the tank of a car or electricity at the socket
v. At Useful (u) energy level that satisfies some demand for energy services like heating, lighting or, transportation etc.

Therefore, the database has been captured including the final energy level information at sectoral level and entire flow of energy including efficiency change at each level. The Reference Energy System (RES) maps all the levels in

developing Energy Plan for the state of Odisha. To represent the entire energy system, the following Sankey diagram shows the energy flow from source to sink in the year 2022 in Odisha[3].

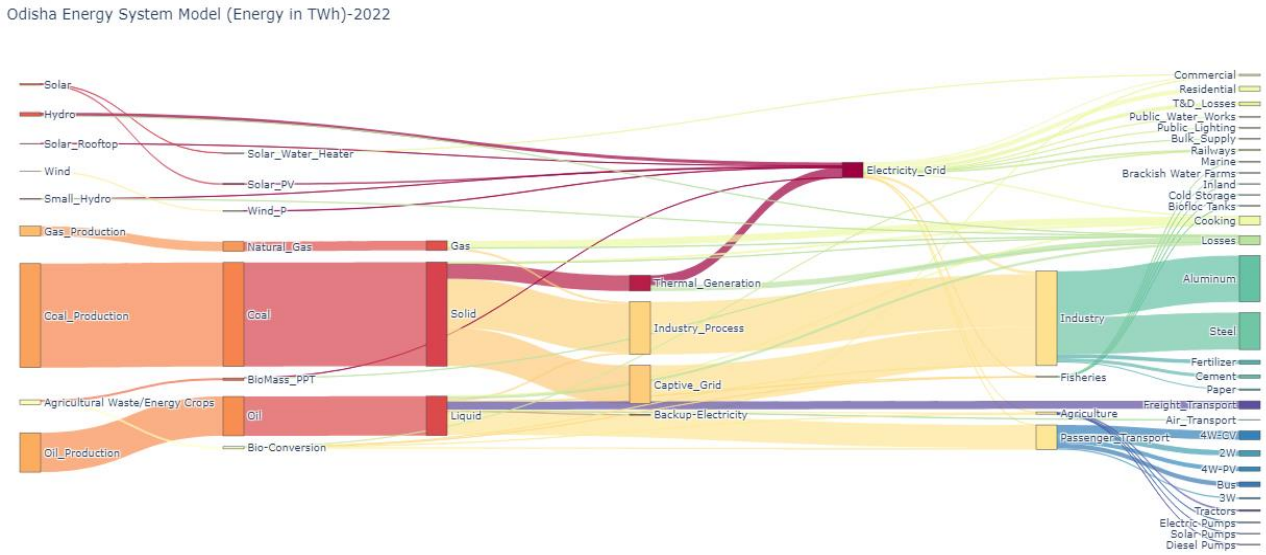


Figure 21: Sankey diagram shows the energy flow from source to sink in the year 2022 in Odisha

The RES for Odisha comprises all technologies that are currently available or are expected to come up in the future. RES is used as the basis for considering each available or most likely available technology/fuel in the future for long terms projections in the energy model. RES would map the flow of energy beginning from its primary level i.e. resource extraction to its final energy level i.e. utilization at demand level. The RES captures all inflow and outflow of energy, conversion efficiency, losses etc. for each and every energy commodity used in the system. The simplistic version of the State Energy Reference system is provided above. **The RES shall be the basis for developing the Energy Plan for the state of Odisha**.

[3] The data used for developing the model is based on the actual values for 2022 received from the respective stakeholders / departments. However, slight differences in values could exist due to the calculation methodology of the model.

3. Baseline Scenario Assessment

The baseline scenario assessment provides the business as usual energy supply and demand situation for the state of Odisha until 2040. The optimal condition identifies the least cost energy supply mix to meet the given energy demand in the state for each time step.

The baseline scenario results are based on the understanding that energy supply, energy demand and related assumptions follow historic trends which may or may not meet the targets for the renewable energy and energy efficiency development set by the state in the Odisha Renewable Energy Policy 2022, SAPCC and SDG targets. Detailed analysis of the baseline scenario has been presented in the "Baseline Assessment Report for Odisha".

The useful energy demand and technical parameters for each energy consuming component of the energy system are provided as input to the model. Based on various Governmental documents, departmental meetings and expert opinions the study further assumes the projected future of the State in various context of energy supply and demand until 2040. These projections are based on the understanding that there are certain policies and plans already adopted by the Odisha State Govt. and in the process of implementation.

The results of the baseline scenario assessment showcase that the major energy demand sectors in Odisha include are Industrial (64%), Passenger Transport (17%) by 2040. It has been observed through the baseline results that across these sectors, economic activities have been steadily growing that can be directly linked to the growth in energy consumption. The trend in the energy consumption of all the sectors between 2022 and 2040 in the baseline scenario are presented in the figure below:

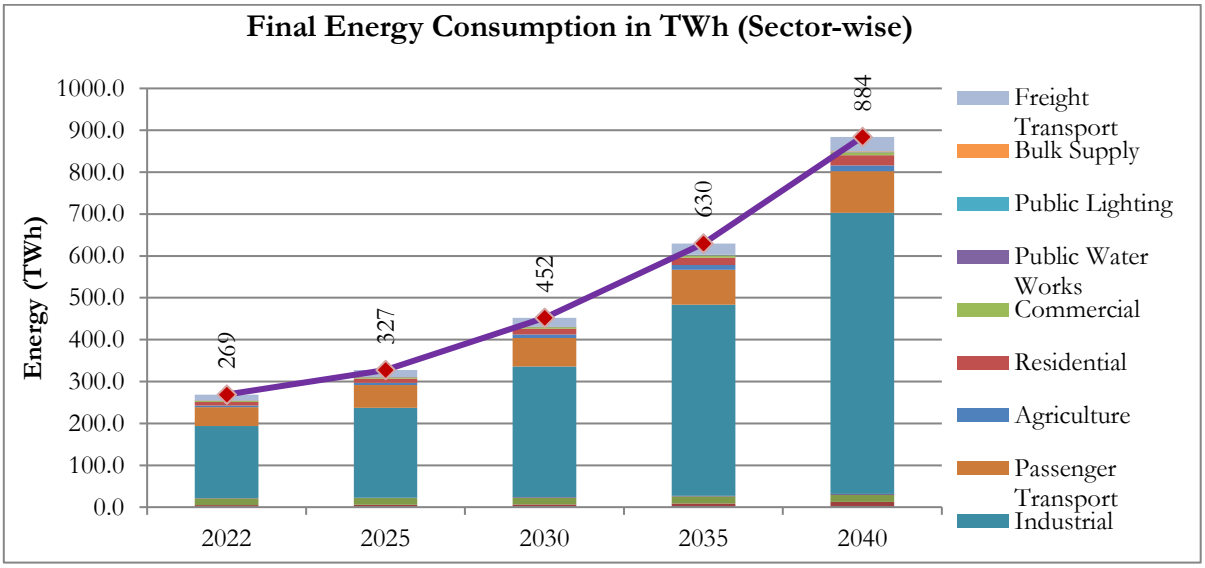


Figure 22: Final energy consumption in Odisha between 2022 and 2040

The section below presents the overview of the Baseline Scenario in terms of the primary energy supply, final energy demand and emissions.

3.1. Primary Supply – Total Energy Mix and Cost

Presented below is a snapshot of the primary energy supply in the baseline scenario in Odisha. For further detailing on the baseline scenario for the state, please refer to Baseline Scenario Report for Odisha.

Primary Energy supply is the natural form of energy commodity which is being used directly to meet the energy demand like Coal, Oil, Gas, etc. Additionally, energy source of energy imported from outside of the state is also considered under the primary energy supply. It is observed that the total primary energy supply (PES) in Odisha is estimated to increase from 276.6 TWh in 2022 to 848.4 TWh by 2040 at a CAGR of 6.4%. Oil, gas, coal, and

imported electricity are major primary energy sources the state will depend upon. Coal will remain the major source of energy in the state comprising of about 58.18% in 2022 and 76.19% by 2040. Within the total PES, coal will continue to remain as the major source of energy primarily for power generation and use in industries.

In the baseline scenario, the share of gas would decrease from 6% in 2022 to 2% by 2040. It is also observed that the bioenergy use in the state is continually increasing until 2040, growing at a CAGR of 6.4%, increasing 4.1 TWh in 2022 to 12.6 TWh in 2040. The figure below presents the share of total primary energy supply fuel wise in the state between 2022 and 2040.

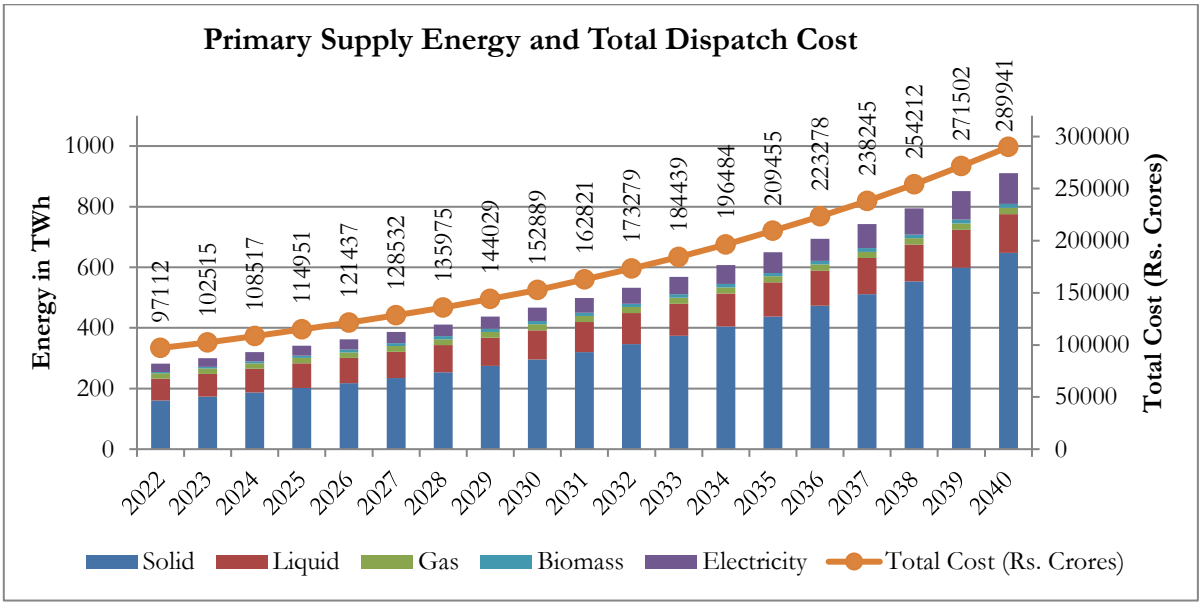
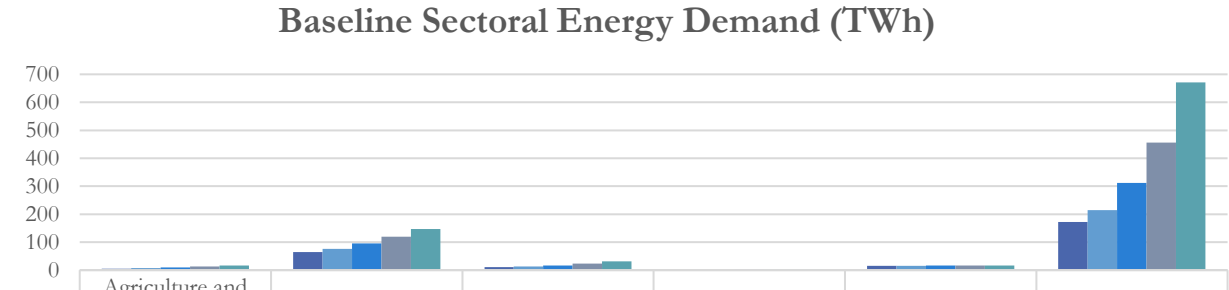


Figure 23: Primary Supply Energy in baseline scenario

3.2. Final Energy Use

The energy demand requirements for various sectors in the State between 2022 and 2040 under the baseline scenario (based on baseline scenario report) is presented in the figure below. As can be seen, the energy demand in the industrial sector is the highest (~76% of the total energy demand in the stat in 2040) followed by the transport sector (16.6% of the total energy demand by 2040).



	Agriculture and allied sectors	Transport	Building	Public services	Cooking	Industries
2022	5.5	64.1	10.9	0.9	15.5	172
2025	7.1	75.9	12.9	1	15.7	214.5
2030	10	95.7	17.1	1.2	16.1	311.9
2035	12.9	119.6	22.9	1.5	16.4	456.3
2040	16.2	146.8	31.3	2.1	16.8	671

Figure 24: Sectors - Energy Demand (in TWh)

In the baseline scenario, the industrial sector energy demand is growing at a CAGR of 7.86% between 2022 and 2040, transport sector at a CAGR of 4.71%, agriculture & allied sector at 6.19%, building sector at 6.04%, public services sector at 4.82% and cooking sector at 0.45%. Break-up of the sectoral demand from 2022 to 2040 is provided in the table below:

State Sector	2022	2025	2030	2035	2040
Fisheries	1.4	1.5	1.7	1.9	2.2
Agriculture	4.1	5.6	8.3	11	14
Cooking	15.5	15.7	16.1	16.4	16.8
Industrial	172	214.5	311.9	456.3	671
Air Transport	0.8	0.8	1.2	1.7	2.4
Passenger Transport	45.1	54.1	68.3	83.5	99
Freight Transport	14.3	16.6	21.3	27.2	34.8
Railways	3.9	4.4	4.9	7.2	10.6
Residential	8.6	10.1	13.4	17.8	24.2
Commercial	2.3	2.8	3.7	5.1	7.1
Public Water Works	0.3	0.3	0.4	0.4	0.5
Public Lighting	0.1	0.2	0.2	0.3	0.5
Bulk Supply	0.5	0.5	0.6	0.8	1.1
Total	**269**	**327**	**452**	**630**	**884**

3.3. GHG Emissions profile of the State

In the Baseline scenario, the combustion emission factors of different commodities like coal, petroleum products and natural gas has been considered from IESS data and the factors are presented in the table below. Further, the same factors has been considered in low carbon scenarios.

Table 10: Combustion Emission Factors

Sl. No.	Commodity	CO_2 Emission Factor (Million-Tons per TWh)
1	Coal	0.3470968
2	Petroleum Products	0.2667240
3	Natural gas	0.1989474

Figure below presents the total emissions from all the sectors of Odisha under the baseline scenario until 2040:

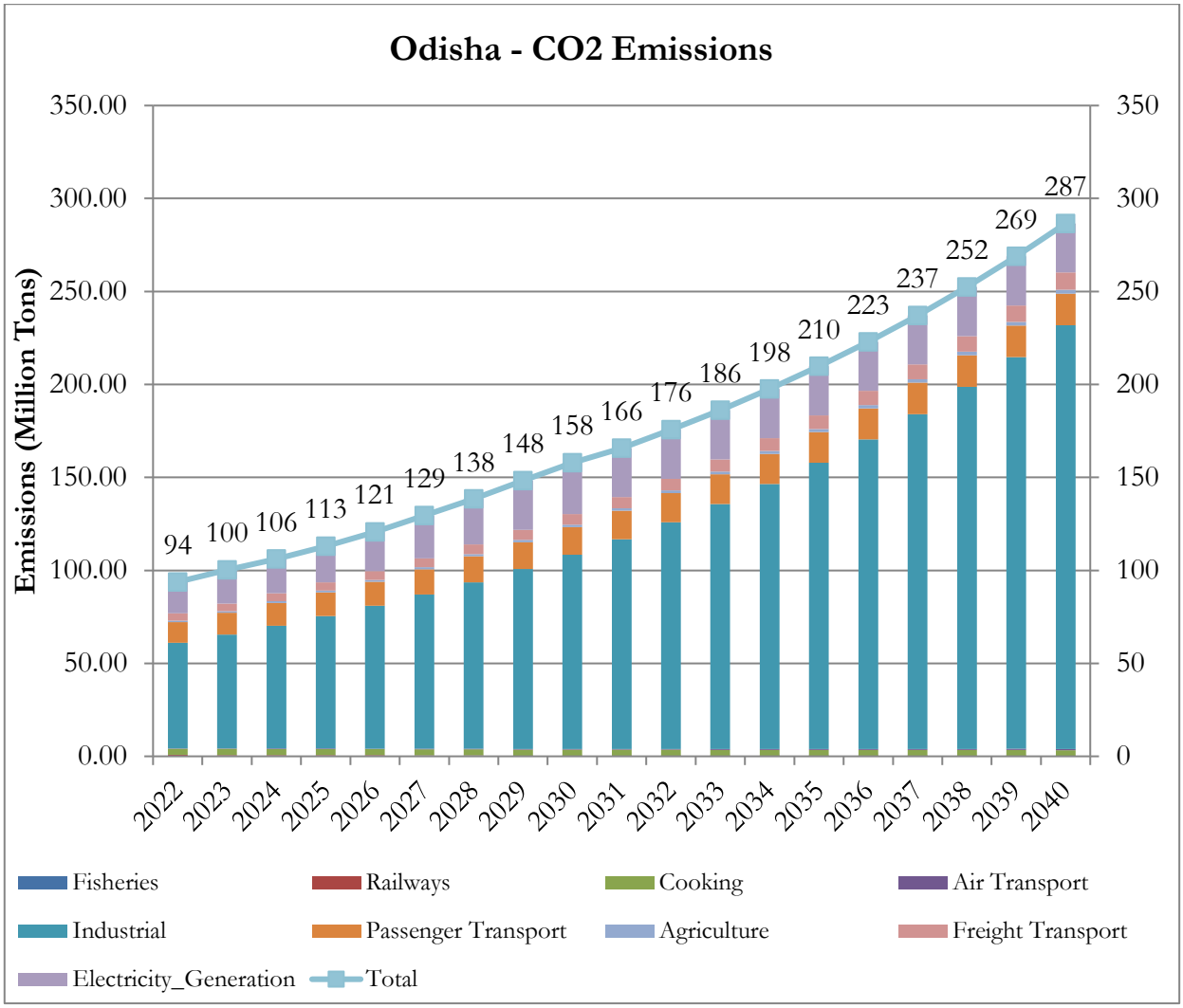


Figure 25: Total CO2 Emissions

From the baseline scenario results, it is clear that within the total PES, coal will continue to remain the major source of energy, primarily for power generation and use in industries, growing at a CAGR of 8%. As a percentage share, coal will comprise ~75% of the total primary energy supply in the state by 2040. The CO2 emissions resulting in this scenario are also alarming high – standing at 287 million tons in 2040 (growing a CAGR of 6.4% between 2022 to 2040). This creates an immediate need for decarbonising the energy supply and demand sectors if Odisha wants to embark on its journey of a clean energy transition over the years.

As such, inputs have been gathered from the state departments on the future energy vision they have set for their respective departments which can help Odisha in its journey towards a clean energy transition. Economic and infrastructural development in the state has led to degradation and over exploitation of natural resources of the state especially water, land and biodiversity, indicating that the state is rapidly exhausting its resources, thereby jeopardizing future generations. Hence, for maintaining the state's economic prosperity in future, concerted efforts would be required to protect the environment and promote sustainable use of natural resources.

The Energy Vision for the state has been developed to address the sustainability issue as well, thereby ensuring an overall economic, social and environmental development of the state. Moreover, the state vision also focuses on promoting energy self-sufficiency through reduction in import of fossil fuels and increasing in supply of energy resources generated within state and by increasing resource use efficiency across the value chain in various economic activities.

For developing the energy vision for the state and different sectors, a total of 17 state government departments have been reached out to. To help the departments develop these visions, multiple rounds of consultations and visits to the departments have been undertaken. The detailed departmental visions can be found on. Details of the departments which have provided their departmental visions are provided in Appendix 3.

Odisha's State Energy Vision is to provide affordable, reliable and clean energy to all in the State and to contribute towards sustainable development of the State and the country as a whole. State energy visions are classified into three main categories: *Improved Energy Access, Cleaner Energy Production and Growth of Natural Capital.* Odisha Energy Plan has been developed in a way such that all three areas are fulfilled through several set of activities over the period of time until 2040. The three pillars of vision are as follows:

1. Achieving higher living standard of the people of the State by providing access to modern energy in an affordable and reliable manner. It envisages:

a) Increasing per capita energy and electricity consumption in the State and thereafter, total electricity consumption and improving the standard of living.

b) Providing adequate supply of clean energy in the State in an affordable and reliable manner.

c) Creating scope of employment in the State in clean energy sector.

2. Ensuring cleaner environment to the people of the State by reducing pollutions and other environmental externalities. It envisages:

a) Utilization of full potential of renewable energy resources available in the State.

b) Promoting use of efficient technologies in energy production and consumption to reduce the consumption of natural resources.

c) Implementing the principles of circular economy by adopting 3R policies in energy production and consumption.

3. Increasing the wealth of the State by ensuring the growth of natural capital of energy and its related resources. It envisages:

a) Ensuring optimal use of energy resources in the State by bringing resource use efficiency in the system.

b) Reducing dependency on imported fuels and increasing optimal use of domestic resources.

c) Recognizing the importance of resource use nexus, creating an integrated planning and monitoring framework for energy production and consumption in the State

Based on these energy visions and the sectoral priorities, a multi-sector approach on the energy supply and demand side has been developed while focusing on the low carbon scenarios. These scenarios are developed considering different set of cleaner options to meet the sectoral energy demand. These include clean energy substitution measures, renewable energy source measures, capacity utilization measures (including utilization of biomass), the industrial energy efficiency measures, energy conservation in buildings, transport modal shift, motor fuel efficiency, etc. The detailed assessment of the low carbon scenarios developed for Odisha has been presented in the "Low Carbon Scenario Report for Odisha".

As a next step, based on consultations with the state nodal agency, two low carbon scenarios, focusing on developing the EP assuming that all RE and EE potential will be tapped by 2040 and 100% decarbonization of demand will be achieved, were considered as future pathways for the energy sector in the state viz. aggressive scenario (LC scenario 3) and decarbonization scenario (LC scenario 4). The two scenarios have been generated through energy systems modelling and will provide a long term energy horizon for the state and assist in strategic energy and integrated assessment of energy-engineering-economy-environment systems. The next chapter provides the assumptions and results of all the low carbon scenarios developed for the state of Odisha.

4. Low Carbon Pathways for Odisha

Odisha is the one of the most energy intensive states in the country. The commercial energy supply is heavily dependent on fossil fuels in Odisha. For example, the share of renewables in the installed capacity in Odisha (excluding hydro) is much lower than the all-India average of ~27%4. At the 2022 level, the total RE installed capacity in Odisha stood at around 2.9 GW out of the total installed capacity of 7.57 GW. Coal based generation has accounted for over 58% of the total electrical energy generation in Odisha. Given Odisha's aim to incentivise and focus on clean energy development within the state as defined in its RE Policy 2022, renewable energy sources can play an important role in this regard.

The distinct and diverse energy realities that characterize Odisha necessitate a more detailed examination of the state's future energy supply and demand situation. Therefore, a multi sector approach on the energy supply and demand side has been developed while focusing on the low carbon scenarios. These scenarios developed consider different set of cleaner options to meet the sectoral energy demand. The low carbon scenarios for Odisha have been formulated based on the following objectives:

- Variation of baseline conditions where certain policy/technology conditions are replaced with low-emission options.
- The increased ambition of the State is in line with state, national and international targets (Sustainable Development Goals (SDG) and Odisha RE Policy, 2022).
- Sector and sub-sector level options to decarbonize the energy sector and identify cost-effective low-carbon options for policy planning.

The following low carbon scenarios have been prepared for the state:

LCS-1: State Policy and Vision Scenario

- This scenario is based on the assumption that the clean energy targets defined in the State RE policy 2022, SAPCC and SDG targets are being met and based on the sectoral priorities in Odisha, a sustained focus that been given to establish aggressive targets for some of the priority sectors (including sub-sectors where such a target did not exist).

LCS-2: Ambitious Scenario

- This scenario is based on the assumption that 70-80% of the renewable energy potential in the state is being exhausted and energy efficiency measures are being incorporated to the extent feasible. The sectoral targets defined under this scenario are more than those taken in the state Policy and vision scenario.

LCS-3: Aggressive Scenario

- This scenario is based on the assumption that the entire renewable energy potential available in the state is being exhausted and energy efficiency measures are being incorporated to the extent feasible. For this scenario, whatever unmet energy demand is there in the state after the RE potential has been exhausted, it is being supplemented through conventional fuel sources.

LCS-4: Decarbonization Scenario

- This scenario is based on the assumption that the entire renewable energy potential available in the state is being exhausted and energy efficiency measures are being incorporated to the extent feasible and that 100% decarbonisation in the demand and supply sectors is being achieved (including RE imports).

[4] https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1785808

For calculation of the RE potential in the state, utilisation of wasteland has also been considered for all the low carbon scenarios for development of solar ground mounted and CBG projects. The total wasteland available in Odisha is 18,42,236 hectares (ha)[5]. For each LC scenario utilisation of wasteland has been taken as a certain percentage, as defined below:

Scenario	Wasteland considered for development of solar ground-mount and CBG projects
LCS-1: State Policy and Vision Scenario	36,844.72 Ha (2%)
LCS-2: Ambitious Scenario	92,111.80 Ha (5%)
LCS-3: Aggressive Scenario	184,223.60 Ha (10%)
LCS-4: Decarbonization Scenario	184,223.60 Ha (10%)

4.1. Assumptions for Low Carbon Scenarios

For LC scenario 1, synergies have been drawn with the SAPCC, SDG targets and State RE Policy 2022. The overall RE installation target has been kept more than the 10 GW RE installed capacity target defined in the State RE Policy 2022. For rooftop solar, the target has been mapped to MNRE defined target of 1 GW. For decentralised solar on farmlands, PM KUSUM target of 0.5 GW has been taken. For ground-mounted solar, floating solar, wind and bioenergy, the maximum potentials in the state have been identified and 50% of the same is said to be exploited in this low carbon scenario.

LC scenario 2 is driven with the ambition of higher decarbonization than the state policy and vision scenario. In this case, 5% of the wasteland is assumed to be available for development of RE power plants which is equal to 92,111.80 ha. For rooftop solar, the target has been mapped to MNRE defined target of 1 GW. For decentralised solar on farmlands, PM KUSUM target of 0.5 GW has been taken. For ground-mounted solar, floating solar, wind and bioenergy, the maximum potentials in the state have been identified and 70-80% of the same is said to be exploited in this low carbon scenario.

Aggressive scenario (low carbon scenario 3) has been developed for each of the sectors is based on the assumption that the entire renewable energy and energy efficiency potential available in the state is being exhausted and remaining energy supply is fulfilled through coal. Since this scenario is defined as the pathway towards 100% RE, it is assumed that 10% of the wasteland is available for RE deployment equivalent to 184,223.60 ha and that entire renewable energy and energy efficiency potential of the state is exhausted.

Decarbonization scenario (low carbon scenario 4) is based on the assumption that the entire renewable energy and energy efficiency potential available in the state is being exhausted and that 100% decarbonization in the demand sectors is being achieved (including RE imports).

[5] https://dolr.gov.in/sites/default/files/Odisha.pdf

Sl. No.	Sector	Particular	Target Year	LCS-1: State Policy and Vision Scenario	LCS-2: Ambitious Scenario	LCS-3: Aggressive Scenario	LCS-4: Decarbonization Scenario
1	**Fisheries**						
	a) Marine	Diesel boats	2040	40%	30%	10%	0%
		Electric boats	2040	15%	20%	25%	30%
		Bio-diesel boats	2040	30%	30%	40%	40%
		CBG boats	2040	15%	20%	25%	30%
	b) Brackish Water Farms	Diesel aerators (2 HP)	2040	5%	0%	0%	0%
		Electric aerators (2 HP)	2040	60%	50%	40%	40%
		Solar aerators (2 HP)	2040	35%	50%	60%	60%
		Diesel Pumps (5 HP)	2040	0%	0%	0%	0%
		Electric Pumps (5 HP)	2040	90%	80%	70%	70%
		Solar Pumps (5 HP)	2040	10%	20%	30%	30%
	c) Inland Farms	Diesel Pumps (5 HP)	2040	0%	0%	0%	0%
		Electric Pumps (5 HP)	2040	80%	70%	60%	60%
		Solar Pumps (5 HP)	2040	20%	30%	40%	40%
	d) Biofloc tanks	Electricity based	2040	80%	70%	60%	50%
		Solar based	2040	20%	30%	40%	50%
	e) Cold Storage	Overall Reduction in energy	2040	10%	25%	30%	30%
	Blending	Bio-diesel	2040	50%	65%	80%	100%

Sl. No.	Sector	Particular	Target Year	LCS-1: State Policy and Vision Scenario	LCS-2: Ambitious Scenario	LCS-3: Aggressive Scenario	LCS-4: Decarbonization Scenario
2	**Agriculture**	Overall energy reduction in the sector due to energy efficiency	2040	1.1%	1.5%	2.0%	2.0%
		Reduction in pumping through Conventional flood irrigation	2040	15%	30%	40%	40%
		Diesel Pumps	2040	0%	0%	0%	0%
		Electric Pumps	2040	75%	65%	50%	20%
		Solar Pumps	2040	25%	35%	50%	80%
		Electrification/Bio-Diesel of tractors	2040	50%	65%	80%	100%
		Blending – Bio-diesel	2040	50%	65%	80%	100%
3	**Cooking**	LPG / PNG	2040	90%	80%	60%	0%
		Electricity	2040	10%	15%	30%	80%
		Biogas	2040	0%	5%	10%	20%
		Solid	2040	0%	0%	0%	0%
		Kerosene	2040	0%	0%	0%	0%
4	**Residential**	Overall energy reduction in the sector by energy efficiency measures	2040	10%	12%	15%	15%
		Grid	2040	90%	85%	80%	75%
		Diesel	2040	0%	0%	0%	0%
		Solar Rooftop	2040	10.0%	15%	20%	25%
5	**Commercial**	Overall energy reduction in the sector by energy efficiency measures	2040	15%	20%	25%	25%
		Grid	2040	85%	80%	75%	70%
		Diesel	2040	0%	0%	0%	0%
		Solar Rooftop	2040	15.0%	20.0%	25.0%	30.0%

Sl. No.	Sector	Particular	Target Year	LCS-1: State Policy and Vision Scenario	LCS-2: Ambitious Scenario	LCS-3: Aggressive Scenario	LCS-4: Decarbonization Scenario
6	**Industrial – Steel, Aluminium, Cement, Fertilizer & Paper**	Energy efficiency improvement	2040	0.9%	1.00%	1.10%	1.20%
		Percentage of electricity used for process energy conversion	2040	1.0%	1.5%	2.0%	2.5%
	Steel, Aluminium & Fertilizer	Coal replaced by hydrogen					
			2025	5%	10%	15%	20%
			2030	10%	15%	20%	30%
			2040	30%	35%	40%	50%
		Coal replaced by electricity	2025	10%	15%	20%	25%
			2030	15%	20%	25%	35%
			2040	30%	35%	40%	50%
	Cement and Paper	Coal replaced by electricity	2025	10%	15%	20%	25%
			2030	20%	30%	40%	50%
			2040	50%	75%	90%	100%
	All Industries	Co-firing by biomass plants	2040	10%	13%	15%	20%
		Bio-diesel	2040	50%	65%	80%	100%
		Captive Plants	2040	Nil	Plants till 2019 are retired	Plants till 2019 are retired	Plants till 2019 are retired
			2040	Nil	New plants added from 2023 are RE based (RE including 4% transmission losses)		
7	**Passenger Transport**						
	a) 2W	EV Penetration	2025	25%	30%	45%	60%
			2030	40%	50%	75%	100%
			2040	100%	100%	100%	100%
	b) 3W	EV Penetration	2025	40%	45%	50%	60%
			2030	70%	75%	80%	100%

Sl. No.	Sector	Particular	Target Year	LCS-1: State Policy and Vision Scenario	LCS-2: Ambitious Scenario	LCS-3: Aggressive Scenario	LCS-4: Decarbonization Scenario
			2040	100%	100%	100%	100%
	c) 4W-PV	EV Penetration	2025	20%	25%	30%	40%
			2030	40%	45%	50%	60%
			2040	100%	100%	100%	100%
	d) 4W-CV	EV Penetration	2025	40%	45%	50%	60%
			2030	100%	100%	100%	100%
			2040	100%	100%	100%	100%
	e) Buses	EV Penetration	2025	40%	45%	50%	60%
			2030	100%	100%	100%	100%
			2040	100%	100%	100%	100%
	Blending	Bio-diesel	2040	50%	65%	80%	100%
8	**Freight Transport**	Electric	2040	1.7%	1.9%	2.5%	2.5%
		Diesel	2040	48.3%	33.1%	17.5%	0%
		Blending – Bio-diesel	2040	50%	65%	80%	100%

4.2. Energy Scenario Comparison

To evaluate different scenarios based on the sectoral interventions considered in different scenarios, the table below provide the insights on key observations for the year 2040. As we move towards the low carbon scenarios, it can be seen that the energy demand across the sectors in gradually decreasing. CO2 emissions are also reducing from baseline scenario to LCS1, LCS2, LCS3 and LCS4, with CO2 emissions being the lowest in LCS4 – decarbonisation scenario (2 MT / year by 2040). As far as the energy mix is concerned, coal comes out to be the major source of energy use in the state in 2040 under the baseline scenario. This picture changes as we move towards ambitious, aggressive and decarbonisation scenarios where renewable energy becomes the major source of energy use in the state by 2040.

Table 11: Key observation from state energy scenarios

Scenario	Primary Energy Supply (TWh) in 2040	Energy Demand (TWh) in 2040	Energy efficiency	Share of RE within the state (%) by 2040	Installed capacity by 2040 (MW)	GHG emission (Mt CO2/ Year) in 2040	Energy Mix for demand sectors (%) in 2040		Change from baseline scenario
Baseline	911	884	11%	7.3%	• Thermal -3253 • Hydro - 2095 • Solar-37211 • Wind - 2514 • Small Hydro - 274 • Biomass- 19 • ISGS - 1755	287	Coal	71.1%	-
							Oil	14.0%	-
							Gas	2.3%	-
							Bio-Diesel	1.4%	-
							CBG	0.0%	-
							Additional RE	0.0%	-
							Electricity	11.2%	-
LCS – 1: State Policy and Vision	895	866	13%	27%	• Thermal - 3253 • Hydro - 2095 • Solar - 106982 • Wind - 27155 • Small Hydro - 219 • Biomass - 217 • ISGS - 1755	198	Coal	48.0%	↓
							Oil	8.5%	↓
							Gas	2.4%	↑
							Bio-Diesel	10.4%	↑
							CBG	0.01%	↑
							Additional RE	20.3%	↑
							Electricity	10.4%	↓
LCS – 2: Ambitious	886	844	15%	74%	• Thermal - 3253 • Hydro - 2095 • Solar - 270881 • Wind - 81768	52	Coal	8.5%	↓
							Oil	5.7%	↓
							Gas	2.2%	↓
							Bio-Diesel	8.0%	

					• Small Hydro - 246 • Biomass - 347 • ISGS - 1755		CBG	0.1%	↑
							Additional RE	65.0%	↑
							Electricity	10.4%	↓
LCS – 3: Aggressive	867	826	17%	77%	• Thermal - 3253 • Hydro - 2095 • Solar - 285690 • Wind - 85666 • Small Hydro - 274 • Biomass - 434 • ISGS - 1755	44	Coal	4.8%	↓
							Oil	3.3%	↓
							Gas	1.7%	↓
							Bio-Diesel	9.8%	↑
							CBG	0.2%	↑
							Additional RE	69.4%	↑
							Electricity	10.8%	↓
LCS-4: Decarbonization	847	806	19%	86%	• Thermal - 0 • Hydro - 2095 • Solar - 316867 • Wind - 90778 • Small Hydro - 274 • Biomass - 434 • ISGS - 1755	2	Coal	0.2%	↓
							Oil	0.3%	↓
							Gas	0.4%	↓
							Bio-Diesel	11.5%	↑
							CBG	0.3%	↑
							Additional RE	75.0%	↑
							Electricity	12.2%	↓

The analysis above clearly represents the benefits to state in shifting away from baseline scenario towards the low carbon scenarios. The share of coal in the total energy mix is decreasing substantially (from 76% in baseline scenario to merely 02.% in decarbonisation scenario in 2040) and the renewable energy share is growing impressively. It is also to be noted that the share of bio-energy is increasing with increasing aspiration, which is in line with the state key objective of efficient utilization of surplus biomass available within the state. The scenarios also takes into the consideration of various policies promoting the use of biomass to produce biofuels and biogas.

Accordingly, GHG emissions are also decreasing substantially, from 287 MT/ year in the baseline scenario to merely 2 MT / year in decarbonisation scenario. The shift in the scenarios is also resulting in reduced energy demand across the demand sectors, majorly due to energy efficiency measures being adopted at a higher scale than the baseline scenario.

All the above LC scenarios are developed by increasing the aspiration towards energy saving through energy efficiency measures and transition to clean technologies and clean energy sources. One of the objectives of these scenarios is also to minimize the energy import dependency by increasing the utilization of domestic clean energy sources. These low carbon scenarios are trying to optimise the land use in the state, by focusing on wasteland utilization and advanced installation setup for renewable energy system like vertical solar PV and agro PV.

One point to consider with the use of wasteland, however, is that in a competitive energy market, any attempt to use waste-degraded land parcels, without policy regulatory support, can bring large-scale disruptions in the quality and cost of power. Project developers tend to favour land that is fertile near the urban areas, in order to avoid the cost on excessive networks for transmission lines that comes as a part and parcel with wasteland utilization for the said purpose. Apart from the socio-economic feasibility study, the solar ground mounted projects require intensive civil infrastructure, which includes drainage, road networks, land conditioning, and power evacuation infrastructure. Therefore, before making any decision on utilization of wasteland, land characteristics, land procurement strategies, and associated operation and maintenance hurdles, if existing will have to be considered.

As a result of increasing ambition towards emission reduction, and increasing targets for various energy efficiency measure, there will a significant implication on the overall system cost and consequently the investment requirement in different scenarios. The figure below highlights the energy cost for 2022-2040 under various energy scenarios. The energy cost here reflects the present value cost (INR Crore 2022) of the energy system by 2040 under different scenarios.

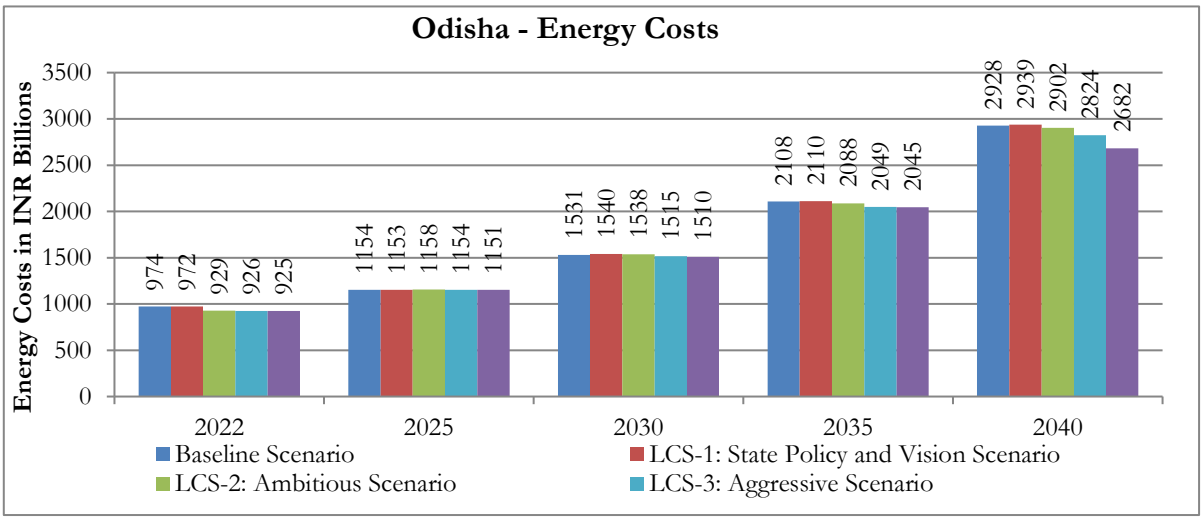


Figure 26: Energy cost for 2040 under various energy scenarios

Based on the energy cost comparison under the different scenarios, the aggressive scenario found out to be the most suitable for the state by having a significant penetration energy efficiency measures, reduced import dependency, and high clean electricity import. Additionally, a zero emission scenario (LC 4) has also considered representing high emission reduction potential but with a higher investment implication. The cost computation excludes the overall system cost involved in integration of renewables in the grid such as grid balancing cost.

How to bring more renewable energy in the State?

In order to understand the implications of an aggressive renewable energy utilization, low carbon scenarios, namely, aggressive and decarbonization have been developed. The aggressive scenario is based on the assumption that the entire renewable energy (that can be developed on waste land) and energy efficiency potential available in the state is being exhausted. For both the scenarios, 92.13 GW + 1.5 million TPD of CBG of RE. This includes:

Table 12: Renewable energy target set under aggressive and decarbonisation scenario

Renewable Energy Technology	Target Capacity (GW)
Ground-mounted solar	83.8
Decentralized solar (rooftop solar, PM KUSUM and AG feeder solarization)	1.5
Floating solar	5
Biomass power plants and waste-to-energy plants	0.45
CBG plants	1.5 million TPD

Wind	8.34
Total	**92.13 GW + 1.5 million TPD**

The decarbonization scenario is an extension of the aggressive scenario. Here is assumed that in addition to exhausting the entire renewable energy and energy efficiency potential available in the state, demand side shift is seen in the state with the 100% decarbonisation of the demand sectors. For this scenario as well, 92.13 GW + 1.5 million TPD of CBG of RE is installed within the state. A key implication of these scenarios is that coal generation capacity would be replaced by the additional RE power generation capacity including RE imports.

Given the complexity of macroeconomic scenario of any state along with cross-linkages with energy demand and supply sectors, it is important to develop an action plan which is **integrated in nature and comprehensive in coverage.** Keeping these two issues in mind the study has developed a detailed Energy Plans (EPs) for the State based on the assessment of an optimization model. The main aim of the EP is to present a holistic picture to the state as to how the energy future energy generation mix and sectoral energy demand will look like under different clean energy transition pathways and what actions the state is required to undertake to meet the targets set under these different clean energy transition pathways.

GIZ has developed an energy model which should be hosted on the state's website and capacity building of state government officials should be undertaken to provide them with the knowledge on how to undertake energy planning exercise in the future. It is further suggested that the EP should be updated every two years to keep it relevant with the changing policy and regulatory landscape in the state. As such, the state should adopt a loop of planning, doing, checking and acting cycle (PDCA cycle) for meeting the energy needs of the state as it will provide a simple and effective approach for solving clean energy transition related issues in the state and managing such a transition effectively.

The fundamental objective of energy planning is to link the energy sector to economy, society and environment through a causal chain relationship. Energy generation is linked to demand of energy which is further linked to economic growth and development. Economic development takes place through social development, employment creation and other economic activities. Generation of energy has a variety of negative externalities, the most crucial one being air pollution and GHG emissions.

- Generation technologies need to be upgraded to higher efficiency and cleaner technologies so that negative externalities can be minimized.
- Access to finance is critical for adoption of such advanced technologies in the market as well as increased awareness among end users on the benefits to adopting such technologies.
- In order to successfully implement such activities, a robust institutional framework should be in place along with requisite policy and regulatory support.

Thus, Energy Plan, apart from being multi-sectoral should also be multi-dimensional, catering to various functional areas as well. An idea of how this has been achieved in case of Odisha is given in the following sections. The following chapters deal with the detailed description of the proposed action plans for each of the sectors in the economy assessed in this study.

5. Detail Action Plans for Energy Supply Sector

The main purpose of developing the action plans is to provide Odisha with suitable pathways of development which can ultimately help the state to reach the goals and materialize the visions into reality within a given timeline. The action plans would also help Odisha to achieve the clean energy targets set under aggressive and decarbonisation scenarios, as deemed more suited. The model test indicates the impacts of each of every action plans proposed on the energy system of the state as a whole, especially in the context of three main policy dimensions:

I. Economic and financial impact of the plan
II. Environmental impact of the plan
III. Social impact in terms of access to energy, livelihood opportunity and achieving a decent standard of living

5.1. Brief Description of Sector

According to the Economic Survey of Odisha, 2022, Odisha hosts 24% of India's coal reserves. The **coal production in Odisha in FY21 stood at 1539.4 lakh MT.**

- Talcher in the Angul district of Odisha hosts the largest repository of power grade coal in India, which helps in catering to the power needs of the state and some of the western and southern states of India.
- In 2020-21, Angul reported a total of 96.7 million metric tonnes (MMT) of coal production.
- The district has total 9 operational coal mines. In February 2022, Government of India auctioned 10 coal mines in the country, out of which 4 are in Odisha, namely, Bankhui, Bijahan, Meenakshi and Utkal C.

In terms of the oil and gas production in the state, Odisha also has a petroleum refinery complex in Jagatsinghpur district, namely, Paradip Refinery.

- The total oil and gas production through the refinery is 15,002 TMT / year.
- This includes LPG (932 TMT / year), polypropylene (678 TMT / year), high speed diesel (BS-VI) (6017 TMT / year), motor spirit (BS-VI) (3260 TMT / year), reformate (96 TMT / year), ATF (463 TMT / year), superior kerosene oil (312 TMT / year), sulphur (350 TMT / year), LCO (1641 TMT / year) and PetCoke (1253 TMT / year) .

Other than this, **Odisha also has six large hydro projects** installed in the state with a cumulative capacity of 2.08 GW. These hydro plants are owned by OHPC and have generated 6168.4 MU in FY20 (GRIDCO 2021).

The major **electricity generation in the state is from coal based plants.**

- State's total generation capacity includes state owned capacity, privately owned capacity (thermal IPPs) and centrally owned capacities (NTPC, TSTPS, FSTPS, KhTPS, etc.) together.
- Transmission license in the state is OPTCL and distribution with TPCODL, TPWODL, TPNODL and TPSODL.
- Over the years, the total RE installed capacity in the state has increased to reach a total of 627.79 MW in 2022. Majority of this capacity comes from solar, amounting to 452.94 MW. The remaining capacity is dividing between biomass power plants, co-gen plants, mini-hydel and waste-to-energy plants. RE-based electricity generation in the state amounts to 1081 GWh.

5.2. Existing initiatives related to energy sector

1. Odisha Renewable Energy Policy 2022

The Policy envisions to establish a robust framework that can enable Odisha to undertake an inclusive journey towards energy transition through higher adoption of renewable energy (RE) in the State's power system. Apart from power sector, it is also required to have parallel and concerted measures around electric mobility, green buildings, low carbon or carbon-free agricultural practices, industrial & mining activities. The Government through this Policy aims to encourage State sector power utilities to foray into RE development in multiple technologies, apart from enabling participation from private sector and Central PSUs (Energy Department 2022).

The policy aims to achieve the following objectives:

- To accelerate adoption of clean energy alternatives and decarbonize the energy sector which includes both grid-based electricity consumption and captive consumption of industrial consumers in the State
- To harness the clean energy potential of the State and make best use of the available resources by facilitating development of green energy projects in the State
- To attract investment in the clean energy sector, create job opportunities and develop the State economy
- To facilitate R&D and promote new initiatives & emerging RE technologies in the State

2. Odisha Draft Electric Vehicle Policy, 2021

The primary aim of the Odisha Electric Vehicle policy, 2020 is to accelerate the pace of adoption of electric vehicles in the vehicle segments especially in the category of two wheelers, three wheelers and LMVs. The policy shall focus to drive rapid adoption of Battery Electric Vehicles to contribute a substantial percentage of all new vehicles in the years to come and bring about improvement in the air quality in Odisha in general and all major cities in particular (Commerce and Transport (Transport) Department 2021).

The key objectives of the policy are as under:

- Promote use of Electric Vehicles across vehicle segments among public in the State by facilitating appropriate ecosystem. The aim is to achieve adoption of 20% Battery Electric Vehicles in all vehicle registrations by 2025.
- Promote manufacture of Electric Vehicles & its components including battery in the State.
- Promote Innovation and facilitate Research & Development in the areas relating to Electric Vehicles & Battery.
- Put in measures to support the creation of jobs in driving, selling, financing, servicing, manufacturing and charging of Electric Vehicles.

3. Order OERC on Net Metering/Bi-Directional Metering & their Connectivity with respect to Solar PV Projects

This order applies to all solar power systems that are connected to the distribution system through an electrical service connection. The solar power system can be roof-mounted, ground-mounted, or installed on an elevated structure for captive use. In its order, OERC recognized that distributed solar generation contributes to a significant reduction in transmission and distribution losses as the generated solar power is consumed locally (OERC 2018).

Key Highlights of OERC's order include:

- OERC has raised the cumulative solar energy capacity at distribution transformer level to 75% of transformer capacity from the earlier 30%.
- There is no cap on the capacity of solar installation at consumer level if it is within the limit of the connected load. The restriction of 1 MW solar capacity at a single location has been removed.
- Two meters would have to be installed by the solar power generator. One for measuring the solar generation and the other for the import and export of power measurement.
- In case of multiple solar generation sources at a single premise, separate solar meters will have to be installed for each of the sources with the facility for the installation of modem along with all the solar meters.
- Electricity generated from a solar PV project will be capped cumulatively at 90% of consumption at the end of the settlement period.
- The carry-forward of excess energy generation will be allowed from one billing cycle to the next till the end of the financial year.

4. Integrated Power Development Scheme (IPDS)

IPDS is a Central Government scheme for strengthening of sub-transmission and distribution network, metering of distribution transformers /feeders / consumers and IT enablement of distribution sector and strengthening of distribution network in urban areas. The IPDS Monitoring Committee of Ministry of Power, in its 4th meeting held on August 6, 2015 had sanctioned INR 327.98 Crores for 5 Circles for NESCO, INR 234.17 Crores for 5 circles for Odisha central DISCOM, INR 260.33 Crores for 6 circles for SOUTHCO and INR 260.76 Crores for 5 circles for WESCO in Odisha (total of 21 circles). For Odisha the following is the status of the sanctions and disbursements under IPDS (IPDS 2023):

Table 13: Achievement under IPDS

Scope of work	Approved Project + PMA Cost (INR Cr.)	Total GoI Grant released (INR Cr.)
System strengthening	1083.24	598.46
IT Phase-II	57.01	27.58

5. Improvement in power distribution system to reduce T&D losses

The distribution utilities in Odisha are operating under a Public-Private-Partnership model. Tata Power owns 51% stake in the four distribution utilities. GRIDCO holds remaining 49%. The private sector investor has committed to reducing AT&C losses to the level of 9.5% to 15% by 2030-31 from the current level of more than 20%.

5.3. Comparative analysis of alternative pathways

It has been estimated that the Aggressive Scenario (LC scenario 3) and the Decarbonisation Scenario (LC scenario 4) both can help the state to reduce the overall primary energy consumption. It stands at 911 TWh in baseline scenario in 2040 and reduces to 867 TWh in aggressive scenario and 847 TWh in decarbonisation scenario in 2040.

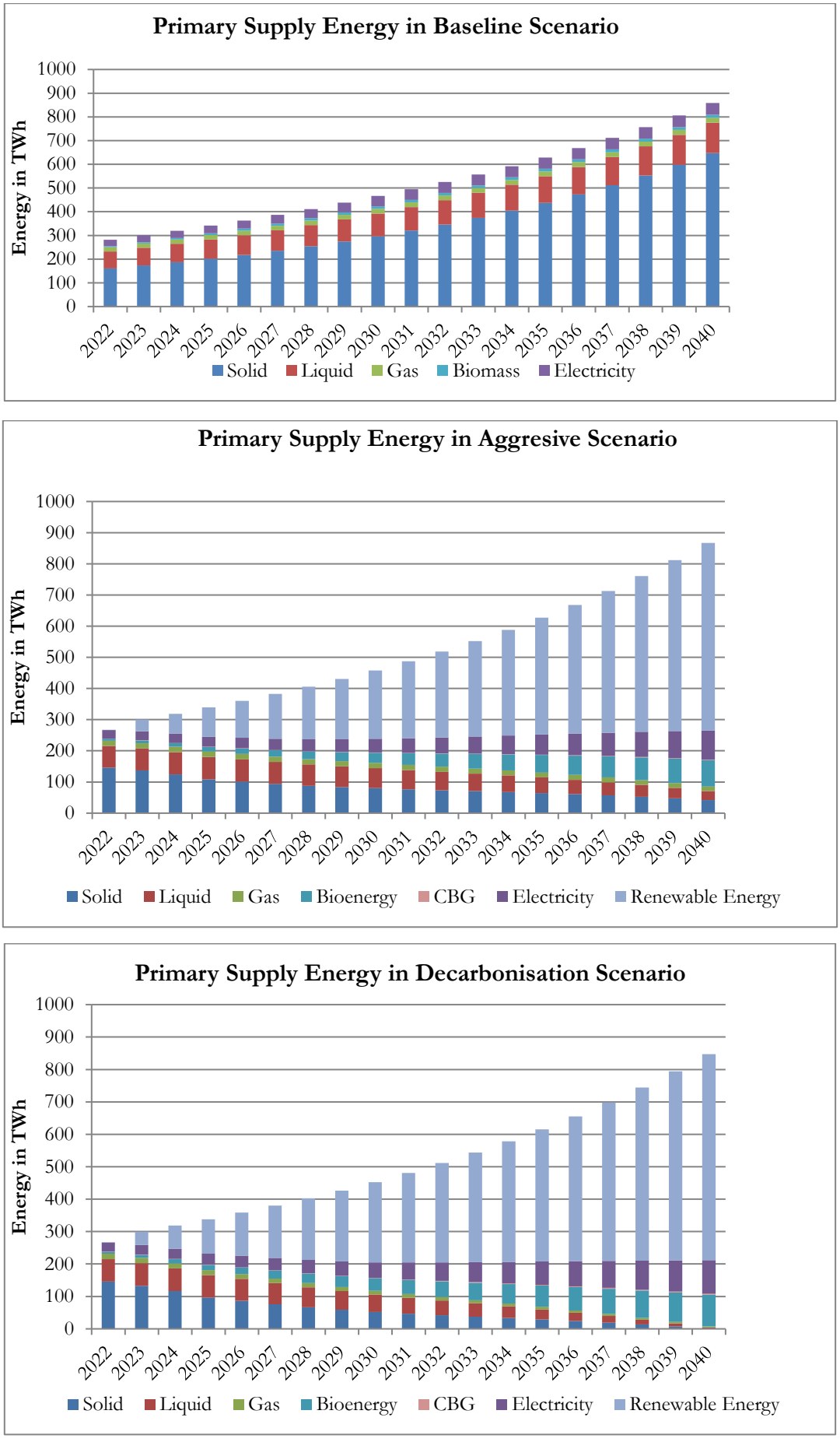


Figure 27: Comparison of primary energy consumption across scenarios

In terms of emissions from the energy sector, both LC scenario 3 and LC scenario 4 can help the State to reduce CO2 emissions. For LC scenario 3 reduce CO2 emissions fall down to 44 Million ton / year in 2040 and for LC scenario 4, it reduces to 2 Million ton / year. This figure for BAU scenario is 287 Million ton / year in 2040 (highest among all scenarios). While LC scenario 4 is envisaged to reduce emissions from both supply and demand side in a balanced manner, LC scenario 3 reduces the emissions mainly from supply side by replacing coal based power generation with RE.

5.4. Sectoral Vision

The targets and potentials for clean energy supply and use considered in the low carbon scenario are based on the energy visions that have been provided by different state government departments. Presented below in the energy vision for the energy supply sector.

Based on discussions with the state government departments, the following targets have been identified to drive the transformation of the energy supply sector of the state to achieve the Vision:

i. **Power Generation – Renewable energy and energy efficiency**

   State has existing renewable-based power generation capacity which is yet to be fully utilized. There is a need to increase share of renewable energy in the total energy mix by focusing on the following thrust areas floating solar projects, wind, CBG projects, biomass power projects, biomass cogeneration power projects, small hydel projects, solar PV, solar water heating systems, etc.

   Vision: Promotion of renewable energy shall be prioritized. State will explore increasing the share of renewable energy to a minimum of 10 GW by 2030.

ii. **Power Generation – Conventional**

   State has existing power generation capacity which is largely under-utilized and there is no immediate plan of introducing efficient power generation technologies. Also, generation potential from renewables in the state is yet to be fully utilized.

   Vision: State will maximize the utilization of existing assets for power generation, reduction of losses, bringing in efficient power generation technologies in the future as much as possible.

iii. **Power transmission and distribution**

   The distribution losses of the state is more than 20% which has negative impact on the commercial condition of the DISCOM of the state. Revamping the power distribution systems can help address this issue

   Vision: State shall work towards reducing the T&D losses to below 10% by 2035 and to below 8% by 2040.

5.5. Action Plans

Power Generation-Conventional

Objective: The state shall focus on adopting efficient technologies for thermal generation such as supercritical, ultra-supercritical technologies. CCUS shall be explored for power plants.

Activity:

A.1: State shall utilize the existing thermal power plants to its optimal capacity

A.3: State shall support industries having coal based captive power plants to achieve RPO trajectory through projects developed within the State.

Power Generation – Renewable

Objective: The state shall maximize the renewable energy resource utilization by promoting technologies and creating enabling environment for financial and regulatory support which can bring share of renewables to 10,000 MW by 2030.

Activity:

B.1: State shall conduct resource potential estimate for all categories of renewable sources within the state.

B.2: State shall explore the potential of developing decentralised solar PV especially building integrated solar PV and agro PV on the farmlands.

B.3: State shall exploit the potential of biomass residue, MSW and cattle waste as feedstock for power development and CBG generation for use across sectors such as agriculture, transport etc. as a clean alternative fuel.

B.4: State shall develop a pipeline of investible projects – floating solar, pumped hydro, large hydro, ground mounted solar etc. for allocation as per the Odisha RE Policy 2022.

B.5: State shall aim to achieve the RPO of 43.33% and 4% Energy Storage Obligation by 2030 as per the trajectory notified by MoP

B.6: State shall ensure grid stability after integration of renewables in the power system.

Power Distribution

Objective:

The state shall urgently focus on reducing the losses in the power system by adopting required technologies. By 2035 state shall reduce the distribution losses to below 10% compared to more than 20% and by 2040 the state shall reduce the T&D losses significantly lower than 10%.

Activities:

C.1: State shall focus on strengthening distribution network by collecting and digitizing the line information and data (including assessment of substations and distribution transformers). State shall use modern technologies like GIS, SCADA and pre-paid and smart meters for digitization of LT distribution network data.

C.2: State shall install infrastructure to prevent losses caused due to theft and damages due to natural disasters

C3: Creating a more robust and secure distribution infrastructure

Table below shows the summary of all activities and their corresponding sub-activities which are to be implemented over the period of time until 2040 to help achieve the targets in Odisha Action Plan. The activities, which is further divided into sub-activities are derived from the State Energy Vision statement. In order to achieve the objective of each sub-activity, multiple projects may need to be undertaken. Identification of these projects would be the next level of action required for implementation of the Energy Plan.

The sub-activities are divided into three time frames: Short Term (2022-2025), Medium Term (2022-2030) and Long Term (2022-2040) and the sub-activities have been sequenced based on the relative importance of activities.

The sub-activities are also further classified into six categories to help assign roles and responsibilities within the implementation agencies:

1. **Technical:** Sub-activities which involve technical studies or infrastructure development.

2. **Financial:** Sub-activities which involve providing direct monetary support in the form of subsidies, financial incentives or waivers to beneficiaries.
3. **Institutional:** Sub-activities which involve reforms in processes/structure of an institution
4. **Policy/Regulatory:** Sub-activities which involve introduction of new regulations/regulatory reforms or new policies/update existing policies.
5. **Capacity building/Awareness generation:** Sub-activities which aims to generate awareness regarding clean/energy efficient technologies/processes as well as enhance knowledge and skills of users regarding use of such technologies and processes.
6. **Market Development:** Sub-activities which help identify and develop new market segments for a clean/energy efficient technology/process. Furthermore, the appropriate implementing agency which are empowered to implement the particular sub-activity has also been provided.

Table 14: Summary of recommendations for energy supply

S.No.	Sub-sector	Recommendation Category	Recommendation	Scenario type	Time Period	Type of intervention	Implementing Agency
1.	**Power Generation-Conventional**	Ensure reduction in emission	Coal Gasification plants	Aggressive	Short	Technical	GRIDCO
2.			Exploring partnership for clean coal technologies	Aggressive; Decarbonization	Short	Institutional	GRIDCO, IDCOL
3.							
4.	**Power Generation-Renewable**	Utilization of renewable energy potential of state for electricity generation	Establishing the actual potential of renewable energy for electricity generation within the state	Aggressive; Decarbonization	Short	Technical	GRIDCO, OREDA
5.			Incentivizing the development of Agro PV in Odisha	Decarbonization	Medium to Long	Financial	OREDA, GRIDCO, DoA
6.			Incentivizing the development of floating solar in Odisha	Aggressive; Decarbonization	Short to Long	Financial	GRIDCO, DISCOMs, Department of Water Resources
7.			Promoting development of wind projects in Odisha	Aggressive; Decarbonization	Short to Long	Technical	OREDA, GRIDCO
8.			Creating a trained workforce for developing and running wind projects	Aggressive; Decarbonization	Short to Long	Market Development	OREDA, GRIDCO
9.			Promoting development of Waste-to-Energy plants in Odisha	Aggressive; Decarbonization	Short to Long	Technical	OREDA, GRIDCO
10.			Provide regulatory support to the private sector to increase penetration of solar rooftop enabling environment for increased penetration	Aggressive; Decarbonization	Short	Regulatory/ Policy	OREDA, GRDICO
11.			Providing avenues of collaboration and knowledge sharing to the private sector to scale up renewable energy in the state	Aggressive; Decarbonization	Short to Medium	Market Development, Technical	OREDA, GRIDCO
12.		Utilization of renewable energy potential of state for	Establishing the actual potential of bioenergy within the state (including biogas, CBG, biomass densification, bio-ethanol production, etc.)	Aggressive; Decarbonization	Short	Technical	GRIDCO, OREDA, DoA

13.		energy generation other than electricity	Providing avenues of collaboration and knowledge sharing to the private sector to scale up bioenergy in the state	Aggressive; Decarbonization	Short to Long	Market Development, Technical	OREDA, GRIDCO, DoA
14.			Devising a strategy around biomass residue supply and demand	Aggressive; Decarbonization	Short to Long	Institutional, Market Development	OREDA, GRIDCO, DoA
15.		Ensure grid stability due to integration of renewables	Undertake advanced load forecasting to ensure grid integration of renewables	Aggressive; Decarbonization	Short	Technical	OREDA, GRIDCO, SLDC
16.			Undertake capacity building of the DISCOMs for managing RE integration	Aggressive; Decarbonization	Short to Long	Technical	OREDA, GRIDCO
17.			Increasing penetration of power storage infrastructure and grid stabilization techniques	Aggressive; Decarbonization	Medium to Long	Technical	GRIDCO
18.	**Power Transmission and Distribution**	Strengthening of transmission and distribution network	Modernize the power distribution system within the state	Aggressive; Decarbonization	Short to Long	Technical	GRIDCO
19.			Planning for smart grid in Odisha	Aggressive; Decarbonization	Short	Policy	DoE
20.			Installation of infrastructure to prevent losses due to theft and damages due to natural disasters	Aggressive; Decarbonization	Short to Long	Technical	GRIDCO, DISCOMs

5.6. Recommendations for Energy Supply Sector

Provided below are details of the action plans defined for the state in the above table:

1. Establishing the actual potential of renewable energy within the State

The State in its Odisha Renewable Energy Policy 2022 has provided the potential for some key sources of renewable energy along with the cumulative target for 2030 (Energy Department 2022). However, there is no independent verification of the achievable potential of renewables in the state such as ground-mounted PV, CBG, waste-to-energy, Agro PV and wind power. The state has set a target of 10 GW of RE installation by 2030; however, the actual RE potential of the state, considering wasteland land utilization and biomass and municipal solid waste utilization is much higher.

The RE potential for Odisha has been presented below:

Renewable Energy Source	Installation Potential
Ground mounted solar (utilizing 10% wasteland)	83.8 GW
Waste to energy plants (using MSW)	40.25 MW
Biomass power plants (using agri waste)	410.89 MW
CBG production potential using cow dung	2353 TPD

As presented in the table above, out of the total land available in Odisha, 18.42 Lakh hectares of land is available as wasteland in the state[6]. In LC scenarios 3 and 4, 10% of the wasteland has been considered for development of RE projects which can lead to 83.8 GW of solar ground mounted project development possibility within the state.

Furthermore, with utilisation of just 2% of the wasteland available in the State, over 10 GW of ground-mounted solar capacity can be added in the State and if the wasteland utilization is scaled-up to 10%, over 80 GW of ground-mounted solar capacity can be added in Odisha.

A conclusive assessment of renewables potential of the state would be critical in developing an updated renewable policy more attuned to the actual resources available with the state. A more in-depth study of the renewables potential of the state needs to be established. As an outcome of the study, a district wise potential assessment of the various renewable sources would be helpful for planning activities aimed at developing a particular renewable source. It is recommended that the energy model of the state be run with the verified potential figures to understand the change in trajectory of the renewable growth for the state.

Employment creation possibility with RE projects

The labour intensive nature of such projects is able to create the maximum employment for every MW of installed capacity.

Table 15: Job creation potential of RE projects (per MW)

Technology	Solar	Bioenergy	Wind
White collar jobs created per MW	7-10	15-18	7-8

Under aggressive and decarbonisation scenarios, if 88.8 GW of solar projects are installed within the state, it has the potential of creating around 6,21,600 – 8,88,000 white collar jobs. With 450 MW of installed bio-energy projects (biomass and waste to energy) by 2040 under aggressive scenario, 8000 jobs can be created within the

[6] https://dolr.gov.in/sites/default/files/Odisha.pdf

bio-energy sector. Installation of 8.34 GW of wind power plants (source: MNRE) have the potential to generate ~67,000 white collar jobs.

These projects are also able to generate induced jobs situated near to the plants such as workshops, welding shops, vehicle repair shops, teal stalls, dabbas (restaurants), barbers, medical store, trolley / tractor sellers, etc.

These can be classified as direct and indirect jobs:

Table 16: Direct and indirect jobs are created through establishment of RE projects

Category of job	Description of job
Equipment manufacture and distribution	R&D, Design (digesters, refineries, components, etc.), Quality assurance, Marketing and sales, Delivery
Project development	Design, Resource assessment, Environmental and social assessment, Financing, Land agreements, Permitting, Selection of supplier
Construction and installation	Plant construction, Pre-processing and upgrading, Processing, Quality assurance, Conversion (heat, power, or fuel)
Operation and maintenance	Operation and maintenance
Cross-cutting/enabling activities	Training, Management & Administration, Insurance, IT, Health and safety, Financing, Communication, power transmission, and distribution
Biomass Production	Cultivating, Harvesting, Transport

2. Incentivizing the development of Agro PV in Odisha

If Odisha sets ambitious targets for renewable energy development, with the ultimate goal of reaching net-zero carbon emissions from energy by 2070 (as per India's target), the share of land directly affected by new renewable energy infrastructure would need to increase drastically. As a result, the state government needs to consider bringing some part of the net sown area for development of solar PV projects. The most suited option in this case is the development of agro PV on farmlands. Agro PV an additional source of income to farmers by selling the surplus electricity to DISCOMs, providing a source of employment generation for marginalised communities, supplying clean energy to rural areas, and increasing the value of local communities; thereby enhancing the rural GDP. As an example, in India, a grid-tied solar panel of 100 MW installed on farmland of 6 acres / MW in the Vidarbha region of Maharashtra generated an income of ~Rs. 21 Lakhs per annum (Mahto, et al. 2021).

Odisha had a net sown area of 54.1 Lakhs ha in FY22[7]. Even if 0.5% of this land utilized for agro PV installation, over 13 GWp of agro PV can be installed in the state. Some sensitivities for agro PV installation possibilities has been provided below[8]:

Percentage of Net sown area utilized for Agro PV installation	Net sown area utilized for Agro PV installation (Ha)	Agro PV installation possible (GWp)
0.5%	27,050	13.53
1%	54,100	27.05
2%	108,200	54.10

The solar panels can be installed with higher ground clearance for letting the crop grow underneath. Additionally, unlike a typical solar farm where the solar panels are tightly installed to maximize land use, in agro PV, the solar panels can be installed with sufficient clearance for easy movement of the farmers and farm equipment. This shall also aid in water conservation on the farmland. Internationally, a recent study in agro PV spread across 6 acres of

[7] https://www.thestatesman.com/india/agriculture-allied-sectors-report-65-growth-in-odisha-1503157104.html

[8] Area required for 1 MWp of Agro PV installation is ~2 Ha (https://www.energyforum.in/fileadmin/user_upload/india/media_elements/Photos_And_Gallery/20201210_SmarterE_AgroPV/20201212_NSEFI_on_AgriPV_in_India__1_.pdf)

land in Oregon State University, Corvallis campus in the US shows that the water conversation improved by 328% due to solar panels. The conservation of water happened due to solar panels acting as a barrier to water evaporation (Adeh, Selker and Higgins 2018). The same is evident from the study conducted in Montpellier, France. This study found that water balance improved by 10–30% in an agro PV system when the light intensity was 50–70% of the full sun radiation. Another modelling study conducted in the same city of France showed a reduction in water irrigation by 20% in lettuce farming (H. Marrou 2013). Odisha, where most of the landmass experiences warm weather for most parts of the year, will substantially reduce water evaporation from agro PV.

Interest from the State in development of Agro PV has already been witnessed. In 2020, SECI signed a Memorandum of Understanding (MoU) with the Government of Odisha to develop Agro-PV projects in the State. According to the MoU, SECI will develop the grid-tied agro-photovoltaic projects in the coastal state in collaboration with the Odisha Renewable Energy Development Agency (OREDA). SECI is following the annual lease model to develop the Agro PV on farmland. Under this model, the government will directly execute the lease deed for a period of 25 years with the farmers without any brokers. The determined lease amount is INR 20,000 / acre annually (Saur Energy 2020).

At a time when many farmers carry debts and struggle to afford seed and essential inputs, the uptake of agro PV is likely to be limited unless the capital costs of installation can be met in whole or part, especially during the sector's early growth phase. The state government could provide early-stage support through capex subsidy or interest subvention on loans. In terms of a direct subsidy support to the developer, an arrangement similar to PM KUSUM can be thought of. State government could provide 30% subsidy on the capex on per MW basis.

The subsidy requirement for different capacity additions (based on the sensitivity analysis) through agro PV shall be as follows:

Table 17: Subsidy requirement for different capacity additions through agro PV

Capacity Addition	Capital Requirement (INR)	Subsidy (INR)
13.53 GW	8,115 Crores	2,434.5 Crores
27.05 GW	16,230 Crores	4,869 Crores
54.10 GW	32,460 Crores	9,738 Crores

In order to accelerate the uptake of agro PV in Odisha, a policy framework setting suitable preconditions is the need of the hour. The immediate requirement is to integrate agro PV as a land use category so that an agro PV system could be designated in the land use plan as a "special area for agro PV", where possible. Such a land category would prevent agricultural land used for agro PV to be governed by non-agricultural land use regulations. This would avoid negative implications on farmers, who may lose tax-subsidies and continued access to agricultural support schemes at the state and central levels.

Further, agro PV is at the interface of the agricultural and renewable energy sector. Accordingly, better coordination between stakeholders across both sectors is needed, especially between farmers and solar developer for projects with distinct ownership of the agricultural land and the PV components. Likewise, incentives for both farmers and solar developers must be aligned and respective benefits ensured. To enhance the synergies between sectors and enable proper agro PV deployment in Odisha, a greater involvement of the Department of Agriculture & Farmers' Empowerment (DoAFE), and a stronger cooperation between GRIDCO and DoAFE is imperative. A proposed approach, is the establishment of a Multi-Departmental Committee for Cooperation on Agro PV, integrating members from GRIDCO, DoAFE, as well as the Science & Technology Department, if required. The Committee could also involve interest groups from industry and agriculture. The objective shall be to ensure sustainable development of agro PV projects on farmlands in Odisha, keeping in view the practical problems farmers could face and what could be the associated solutions so as to turn farmer community into energy suppliers in the state and providing them with an avenue to earn additional income.

An example of agro PV installation in Gujarat has been provided below (NSEFI 2021)

GSECL Harsha Abakus plant near Panandharo, Gujarat - 1 MW

Parameter	Description
Date of commissioning	28.04.2016
Installed capacity DC [KWp]	1000
State, city	Gujarat, Amrol
GPS location	22.37903; 73.05033
Type of project	Commercial
Project developer	Gujarat Industries Power Company Ltd. (GIPCL), in-house development
EPC	GIPCL & local companies
Ownership structure	GIPCL
Operation & Maintenance	GIPCL
Financing structure	3.44 Rs. /kWh in 2019 Generated power is directly fed into rural grid (11kV rural feeder in 12km distance) T&D losses reduction: Down from 8 - 10% to about 1% Investment: 6 Crore INR/MWp; 60,000 INR/KWp
Type of agro PV plant	Interspace / Overhead stilted hybrid
Module technology	Monofacial, polycrystalline (310Wp)
Mounting structure	• 1 to 3 m horizontal mounting height • Different configuration of PV arrays with gaps between panels of 0 / 100 / 250 mm • Cable were put around agricultural fields, resulting in higher costs due to longer lines, partly put under the ground up to 2.5 m deep
Tracking	5-28-degree manual tilting due to season every 2 months
Cleaning & water management	• Manual cleaning with telescope cloth • Cleaning period: Each 10 days / module • Water consumption approx. 3 l / module, own borewell to get water for cleaning • Total water consumption: 200,000 litre/MWp/yr. • No rain-gutter and no rainwater harvesting • Water management system installed by the company Jain Irrigation
Agricultural aspects	Loamy sand type soil, irrigation required, tractor can go between panels and partially below panels (which may need to be tilted to low angle)
Crops	• Kharif: Groundnut, soybean, pearl millet, cotton, green gram, pigeon pea, maize, cluster bean • Rabi: chickpea, wheat, mustard, lucerne, vegetables • Summer: additionally, sesame, fodder, black gram
Crop cultivation	• More than 40 crops tested • Conventional agriculture, non-organic with use of fertilizers

The panels are installed on a mounting structure at a height of 3 meters. Seasonal tilt is manually adjustable. This plant features differing inter-module and inter-array gaps in order to study the impact of different shading patterns on crop growth.

3. Incentivizing the development of floating solar in Odisha

The importance and potential of floating solar in Odisha has been widely recognised in the Odisha Renewable

Energy Policy 2022. In the first phase, the State has prepared pre-feasibility report (PFR) for more than 5,000 MW floating solar potential. Floating solar projects have an inherent advantage of avoidance of conservation of land and the related cost to acquire and maintain the site. Other benefits include a decrease of temperature-related energy yield losses due to the cooling effect on panels installed above water and a reduction of water evaporation. The State is offering multiple fiscal and financial incentives for development of floating solar projects in Odisha such as exemption of fifty (50) paisa per unit on electricity duty, 50%) exemption of cross-subsidy surcharge, exemption on STU charges and wheeling charges, exemption on stamp duty purchase/lease of land, land conversion charges and registration charges, no clearance from State Pollution Control Board for wind projects, etc. (Energy Department 2022).

To ensure faster deployment of such projects in the State, the first step is to undertake techno-economic and financial feasibility of such potential projects. This is to understand the various project aspects covering technology, design, water cooling methods, finances, gender, environment, social maintenance, and occupational health that can impact the floating solar PV deployment.

The Odisha Renewable Energy Policy 2022 sets ground for various fiscal and financial incentives for the floating solar project development. In term of technical savviness, the State can look to partner with R&D centres nationally and globally to develop state-of-the-art cost-effective technology. A case in point is exploring avenues to tie up with Norway which has become one of the partner countries in Make In Odisha conclave 2022. Five Norwegian companies working in the renewable energy sector were part of Make in Odisha with a strong grip on ocean industry. Their expertise can be leveraged to develop floating solar projects in the State.

The Odisha Renewable Energy Policy 2022 is already encouraging R&D activities for advancement of new RE technologies in the State. Such a global collaboration can be used in the State's advantage to holistically develop the sector. Such R&D activities can also be integrated in the proposed Renewable Energy Research Institute to be developed in the State where RE-focused private sector / industries can also be roped in to facilitate technology dexterity and provide opportunities of further scale-up of the sector.

4. Promoting development of wind projects in Odisha

Odisha Renewable Energy Policy 2022 aims to provide an enabling environment for prospective wind power plant developers to harness the available quantum of wind power in the best possible manner. Similar to floating solar projects, the State is offering fiscal and financial incentives such as exemption of fifty (50) paisa per unit on electricity duty, 50%) exemption of cross-subsidy surcharge, exemption on STU charges and wheeling charges, exemption on stamp duty purchase/lease of land, land conversion charges and registration charges, no clearance from State Pollution Control Board for wind projects, etc. for development of onshore and offshore wind projects (Energy Department 2022). These incentives are likely to augment the development of wind projects in the State.

In terms of technical requirement, offshore wind projects, in particular, call for high levels of customization and planning over their lifecycle. The type of foundation used and the technologies employed for construction are site specific and depend heavily on parameters such as the depth of water, type of seabed, ocean currents, climatology, and sea conditions. Further, fishing is a major activity that affects the livelihoods of communities and the economy of Odisha, and the impact of offshore projects on fishing and ancillary activities is needed to be studied. To ensure faster deployment of such projects in the State, such techno-commercial analyses have to be undertaken to understand if such projects can be developed in Odisha.

Secondly, localization of manufacturing facilities for different components of an offshore wind farm needs to be considered by the State Government. Odisha can be developed as a manufacturing hub for offshore wind projects. The components associated with offshore wind energy are larger than their onshore counterparts, with longer blades and support structures. Transportation of these components across land poses a major challenge in India. This can be mitigated by siting the required manufacturing facilities, supply chains, and infrastructure close to ports such as

Paradip, Gopalpur, etc.

In addition, the State needs to explore avenues of collaboration between government and private sector, financing mechanisms, and robust supply chain to bring down costs for wind energy projects. Bringing the costs down for offshore wind projects is fundamental to get the industry moving forward. One possible way to do this is to invest in R&D of wind projects through collaboration between government and private sector. The proposed Renewable Energy Research Institute in the State is likely to meet that objective. Further, within the private sector, collaboration between domestic and international companies could also be explored. This is necessary to ensure international expertise are brought to the sector to develop state-of-the-art wind projects in Odisha. An extension of this could be exploring collaboration between independent power producers and wind OEMs to design more customized wind turbines suiting the local environment.

5. Creating a trained workforce for developing and running wind projects

NIWE has estimated wind potential of ~12 GW in Odisha at a hub height of 150 meter. There could be an opportunity for the State to leverage the potential through use of new wind turbine technologies. In this regard, the State can focus on building human capabilities in the State for development and O&M of wind projects. This would create new avenues for employment in the State. Ministry of New and Renewable Energy, GOI already runs the Vayumitra Skill Development Program (VSDP), with NIWE as the Nodal Agency. The objective of the programme is to create skilled workforce for the Indian wind energy sector so as to achieve the Government of India targets (NIWE 2023). In the first phase, the following three major areas / job levels were identified namely:

- O&M Electrical & Instrumentation Technician – WPP,
- O&M Mechanical Technician – WPP
- Site Surveyor – WPP based on the discussions and demand of the wind industry.

The proposed "VSDP" is designed in line with the National Skill Development Corporation (NSDC) of the Ministry of Skill Development and Entrepreneurship, Government of India. Through the proposed Renewable Energy Research Institute, the State could explore partnership with NIWE to train the workforce in Odisha to set up and run wind projects in the State. The trainings could be focused on the technical & management, policy & regulatory, and economics of the wind sector. Opportunities for integration of these course in the current curriculum of different graduate colleges and universities in Odisha could also be explored alongside designing technical ITI / Diploma courses in both offshore and onshore wind sector.

6. Promoting development of Waste-to-Energy plants in Odisha

In Odisha, 2100 MT of MSW is generated every day; however, MSW had not been harnessed systematically on a significant scale for power generation (State Pollution Control Board, Odisha 2020). Majority of this waste is dumped in the open. For MSW-based plants, dump yards are a major contributor of methane emissions whose global warming potential is 25 times more potent than carbon dioxide over 100 years. Dump yard gases also tend to move underground and potentially cause fires and explosions. Further, the leachate that accumulates in the dump yards / landfills contaminates the soil and groundwater. Processing of 1 TPD of MSW is able to abate ~42 tons of methane into the air. Further the GHG emission reduction possible from the MSW based W2E plants is presented below (PwC analysis):

Table 18: GHG emission reduction from MSW based Waste-to-Energy plant

Type of project	GHG emission reduction
1 MW MSW based power plant	• CO2 reduction – 5920.36 tons annually • NOx reduction – 14.92 tons annually • SOx reduction – 44.28 tons annually

So far, no W2E have been installed in the State. Development of such projects would also contribute towards the implementation of the State Action Plan on Climate Change (SAPCC) and Swachh Bharat Mission. Such plants

could initially be developed on PPP mode whereby the plants can be managed by private sector entities and waste could be transported to the plant location by municipal corporations. The local municipal bodies in Odisha need to promote segregation of waste at source. This behaviour change on part of the municipal corporations and the masses is required for optimal utilization of municipal machinery and workforce, efficient infrastructure operations, and enhanced environmental outcomes. The segregation of waste at source shall also promote circular economy through promotion of 3Rs concept – reduce, reuse and recycle. Furthermore, the MSW based W2E plants are also able to create jobs in the economy, as shown below (PwC's analysis)[9]:

Table 19: Types of jobs created by Waste-to-Energy plants

Type of plant	Direct job creation	Indirect job creation	Job creation for women
1 MW W2E power plant	23-25 people	350 indirect jobs are created daily just through transportation and supply of MSW to the plant	• 2-3 women in skilled job category • 10-15 women / MW are engaged in MSW sorting and rag picking

For faster implementation of waste to energy projects in the State, tariff for waste to energy needs to be determined otherwise the waste to energy tariff notified by CERC could be encouraged. Alongside, standard model bidding documents are needed to be made available to the project developers which could provide applicants with information to assist the formulation of their bid application for W2E projects. This shall also ensure transparency in the bidding process and aid in the selection of the best suited vendor for setting up the W2E projects as per the requirements of the State.

7. Provide regulatory support to the private sector to increase penetration of solar rooftop enabling environment for increased penetration

The current solar rooftop installation of the state is around 23 MW (Source: GRDICO). As such, promoting decentralised solar including rooftop solar (RTS) should be the recommended step to increase penetration of solar power in Odisha. To ensure faster implementation of RTS in the State and consumer grievance redressal, a dedicated unit within the DISCOMs in the State could be set up provide pro-active support to the customer as well as project developer. This unit could also be tasked with faster response to customer applications, data monitoring, consumer awareness with respect to MNRE' rooftop solar program, faster release of subsidy under program to beneficiaries, etc.

In terms of the regulatory support that can be provided to stimulate the market for RTS in Odisha, synergies could be drawn with the RTS policies of relatively mature markets such as Gujarat, Andhra Pradesh, Telangana, Tamil Nadu, Delhi, etc. After a deep analysis of the respective policies of these states, the following suggestions are provided for Odisha:

- **Provision of Loans:** Each state studied has a provision for the individuals under residential sector availing loans for solar as part of home loan/home improvement loan. Odisha can follow a similar approach. This will help residents get associated tax benefits and lower interest rates, providing indirect financial incentives to beneficiaries.

- **Incentives in form of exemption from electricity duty**: The net metering provisions for the states studied provide exemption from a wide range of charges including electricity duty. Exemption from electricity duty can help reduce the financial burden on beneficiaries and help in the uptake of solar rooftop PV in the state.

To encourage installation of RTS in Odisha, the State can take a focused city approach in the short term, focusing on smart cities to propagate development of RTS. These smart cities could be assigned specific time bound solar

[9] Based on secondary research and consultations with industry stakeholders

rooftop targets by the Government. In the next phase, urban local bodies could be roped in to generate awareness among consumers by developing programs and launching innovative campaigns to enhance public's knowledge about RTS, encouraging consumer confidence and helping consumers with decision making on whether to install RTS on their properties or not. One way to encourage potential customers is to prepare and present case studies on existing successful RTS installations (which could come from successful cases in smart cities in phase 1).

8. Providing avenues of collaboration and knowledge sharing to the private sector to scale up renewable energy in the state

For renewable energy to make a dent in conventional energy market in Odisha, it is pertinent that a part of the private sector investment in the conventional energy sector gets diverted towards RE. The Government of Odisha can set out a roadmap for the year 2040 for advancement in various sectors including clean energy. As part of this roadmap, knowledge exchange could be one of the key components wherein the state of Odisha can collaborate nationally and internationally to share their experiences and learn from the different actors. Further, the stakeholders can promote a dialogue in research and innovation within the area of clean energy. One of the easiest way for Odisha to facilitate this collaboration is through the proposed Renewable Energy Research Institute (RERI) which has also been prioritised in the Odisha Renewable Energy Policy 2022.

- By jointly partnering with stakeholders such as industry, academia and policy makers, the RERI could harness the power and expertise of energy sector academics, as well as state-of-the-art technology, to scale up clean energy deployment and investment. The industrial members could support the RERI in developing and implementing innovation strategies which will set mission-oriented research and innovation priorities and create a successful collaboration that supports the net-zero energy transition in the state.
- To accelerate technology / clean energy solution development, RERI could provide industrial players with multidisciplinary technical support, cutting edge research equipment, and access to the latest scientific research in clean energy.
- The RERI could work with corporate partners and investors to provide companies with test-bedding sites, ranging from high-tech lab facilities to specialized test centres, to safely trial their ideas and innovations in a controlled environment. Business acceleration support, including strategic advisory and networking sessions shall also be provided to industrial players.
- The Institute could also focus on providing advocacy support and research on clean energy policy matters for policy makers in the state alongside providing assistance to them by offering quantification of various clean energy policy aspects for timely decision making.
- Such policy assistance could be mobilized through a network of in-house technical experts offering policy advisory, trainings / webinars and peer-to-peer learning opportunities to help policy makers in Odisha to tailor policy solutions according to the state's priorities and offer opportunities to foster national and international collaboration on policy innovations.
- The RERI could also aim to serve as a knowledge portal for clean energy resources including policy best practices, data, and analysis tools and share the same with energy experts in the state, policy makers and other relevant stakeholders.
- Tech Summits could also be organised under the RERI bringing together technology innovators, scientists, entrepreneurs and policy makers to work together on challenges including the norms and governance of future technology under the cross-cutting theme of data within the clean energy sector.

9. Devising a strategy around biomass residue supply and demand

Odisha has targeted generation of energy from biomass as part of its Odisha Renewable Energy policy 2022. However, there is a pressing need to formulate strategies around strengthening the biomass supply chain. The large-scale use of biomass for energy generation could play a significant role in stimulating the local economy and in augmenting industrial development. One of the key challenges faced by the biomass sector is linked to the supply chain management of raw biomass and biomass pellets and briquettes.

The need of the hour is to establish a reliable supply chain for biomass which includes collection, transportation and handling of biomass feedstock. Given that biomass resources are available across different locations in Odisha, waste processing plants can be set up and mapped using the geographic information system (GIS). As these plants would supply biomass, the real-time location of transport vehicles from these plants to consumption centres can be tracked using GIS mapping in order to ensure supply chain optimisation. Subsequently, storage options by industries and thermal power plants can also be planned in the vicinity of their consumption centres / thermal plants / industrial units.

Alongside securing the supply of biomass in the State, an equal demand for this feedstock for energy generation is also required to be created. The first step shall be to ensure buy back mechanism from industries for the use of raw or densified biomass as an input in their industrial processes. Industries are required to be mandated to sign long-term procurement contracts with biomass suppliers to encourage a sustained supply of biomass for industries processes.

This also stands true for thermal power plants in the State which are required to undertake 5-10% biomass co-firing in thermal power plants (Source: MoP). GoO needs to mandate thermal power plants to sign long-term (7 years and above) contracts with biomass pellet manufacturers to them to set up new factories for producing biomass pellets and supplying them in a sustained manner to TPPs. One problem to consider here is that currently, the technology for torrefied pellets is still at a nascent stage of development in India. It is not easily accessible to small entrepreneurs due to the higher cost of imported machines and lack of sufficient equipment manufacturers offering the technology in India. However, co-firing with torrefied biomass pellets makes more sense for TPPs as they have more energy density, and their characteristics are closer to that of coal. Therefore, Odisha could have the early mover advantage by the means of setting up torrefied biomass pellet plants through R&D carried out under the gamut of proposed Renewable Energy Research Institute. These torrefied biomass pellets could also be supplied to the neighbouring states, creating additional business opportunities for pellet manufacturers.

Another point to consider is developing a market mechanism for biofertilizers / bio-manure (a by-product of CBG and biogas production). The slow uptake of bio-manure discourages private sector investment in the biogas and CBG sectors. Thus, Odisha will need to create a structured market for selling bio-manure at fixed prices so that the returns from such sales can add to project returns and improve project financials, further creating incentives for private sector investments in the CBG / biogas sector in the State. In 2021, NITI Aayog set up a task force for the production and promotion of cattle dung-based biofertilizers and organic fertilisers. This task force aims to encourage commercial production, packaging, marketing and distribution of biofertilizers – including the development of brands – and address challenges in marketing and certification. Tie ups could be explored between this task force and the state nodal agency in Odisha to include the marketing and distribution of biofertilizers and bio-manure which are by-products of CBG production or biogas-to-power production. This buy back mechanism shall create encourage the investment in the CBG / biogas sector by the private sector.

10. Undertake advanced load forecasting to ensure grid integration of renewables

With increasing share of variable renewable energy sources, grid balancing may require additional focus. Advanced load forecasting techniques would be required to match demand and supply on real-time basis so that there is no threat to grid security. The hydro sources of Odisha would provide an advantage in balancing the grid. Such sources need to be strategically utilised for RE integration. Battery technologies can also support integration of renewables. The economics of battery technology is improving and is expected to be competitive around 2030. A mix of pumped storage plants which provide grid scale storage and batteries which may be for relatively smaller scale storage would need to be implemented to integrate RE in the system without threatening grid security.

11. Modernize the power distribution system within the state

As with the national and global level cases, the modernization of the electricity distribution grid is a critical area that can help the state adapt to the changing landscape of energy scenario in the state. The key drivers for a smart, modern distribution grid are as follows:

a) The share of renewables is expected to grow in the state and as per the aggressive scenario, the state is expected to have a renewables capacity of 97.87 GW by 2040 (combining solar, biomass and mini-hydro). A power system of this size with an increased share of renewable energy requires smarter systems to manage it efficiently and ensure its stability and reliability. Such systems can help in implementing multiple options for peak load management from direct load control to consumer pricing incentives.

b) The share of EV in the passenger transport in the aggressive scenario is set to increase expected to grow at a rate of over 30% from 2022 to 2040. This upsurge in EV penetration will require electrical distribution infrastructure upgrades and smarter systems are required which will control/limit simultaneous charging of hundreds of EVs from the same feeder.

c) The state had T&D at more than 20%. While efforts are underway to reduce these losses, a modern distribution grid infrastructure will help monitor, measure and even control power flows in real time that can help identify losses and thereby appropriate technical and managerial actions can be taken to arrest the losses.

d) A modern distribution grid can help in improving financial health of utilities by better asset management, reduction in power purchase cost through increased grid visibility and better control of peak demand.

e) The user can also benefit from a smart grid through improved reliability and quality of supply, providing option of reducing power costs through consumption optimization.

Modernization of the distribution grid entails installation of a smart grid – an electrical grid with automation, communication and IT systems that can monitor power flows from points of generation to points of consumption (even down to the appliances level) and control the power flow or curtail the load to match generation in real time or near real time.

The traditional electric grid needs to build additional layers of automation, communication and IT systems to transform to a smarter grid. The pre-requisites for the same are given below (India Smart Grid Forum 2017):

a) Supervisory Control and Data Acquisition (SCADA) and Distribution Management Systems
b) Distribution Automation and substation Automation
c) Advanced Metering Infrastructure (AMI) or Smart Metering
d) Geographical Information System (GIS)
e) Peak Load Management
f) Power Quality Management
g) Outage Management System
h) Distribution Transformer Monitoring System
i) Mobile Crew Management System
j) Application Integration
k) Modernization of the substations with modern switchgear and numerical relays
l) Distributed Energy Resources and Renewable Energy Integration
m) Customer Care Centre
n) Customer Engagement
o) Cyber Security
p) Wide Area Measurement (WAM) and Control Systems
q) Forecasting, Dispatch and Settlement Tools
r) Enterprise Application Integration Analytics (converting data into business intelligence)

The installation of a smart grid is a prerequisite for introducing dynamic pricing – a concept of reducing peak load by incentivizing off load consumption through lower power charges. Smart grid network assists in dynamic

pricing experiments which intend to gather information about how consumers respond to electricity prices and help identify the most promising mechanisms suitable for wide-scale deployment.

In case of Odisha, the building block to implementation of smart grid is infrastructure and financial assessment followed by implementation on pilot basis in the short term. Based on the learnings from pilot initiatives, the roll out can be expanded across the state over medium to long term.

The recommended actions for smart grid roll-out in the state from short to long term is summarized below:

Table 20: Recommended actions for smart grid roll-out

Short-term	Medium-term	Long-term
Identify SG Pilots and undertake full SG roll out in pilot project cities	SG roll out in all urban areas taking learnings from pilot projects	SG rollout across state
Assess and undertake infrastructure for AMI roll out on pilot basis	State-wide AMI roll out for customers with 3-phase connections	State-wide AMI roll out for all customers
Assess utility-wide deployment of Wide Area Monitoring Systems (WAMS)	Deployment of WAMS at all substations and grid connected generation units	Continued deployment of WAMS at all substations and grid connected generation units
Undertake Cost-Benefit Analysis of pilot's projects and assessment of direct and indirect benefits to consumers and other stakeholders	Standards Development for Smart Infrastructure (SEZ, Buildings, Roads/Bridges, Parking lots, Malls)	Continuous Research & Development; Training & Capacity Building
Initiation of Customer Outreach and Engagement Programs	Development of business models to create alternate revenue streams by leveraging the smart grid infrastructure to offer other services (security solutions, water metering, traffic solutions etc) to municipalities, state governments and other agencies; integration of meter data with other databases etc.	
Research & Development, Training & Capacity Building – at least 20% Utility technical personnel to be trained in smart grid technologies	Continued customer outreach and engagement programs	

12. Developing climate resilient infrastructure

Odisha is vulnerable to natural disasters such as cyclones. It is essential that climate resilient T&D infrastructure is developed to ensure minimal damage and ensure quick restoration of power supply. State is already developing such infrastructure. Focus must continue on developing climate resilient infrastructure. The RE Research Institute can also undertake research on this agenda.

6. Detailed Action Plans for Energy Demand Sectors

6.1. Agriculture Sector

Overview of Sector

Agriculture sector in Odisha plays a crucial role in ensuring food security and sustainable growth of economy in India. Odisha's share in total geographical area of India is 4.87%, while it contributed nearly one-eleventh of the total rice produced in the country (8.84%) in FY 2020-21.

The agriculture sector is a major area of economic activity in Odisha after the industry and mining sector and it contributed about 20.6% to total Gross State Value Added (GSVA) in FY 2021-22.

- The agriculture and the allied sector in the state grew at 7.4% over the previous year against the national level agricultural and allied sectors GVA growth rate of 3.32% in the same year despite pandemic.
- The cropping intensity i.e., growing of a number of crops from the same field during one agriculture year, for Odisha is 158%, while the national average is 136%.

Odisha has two major cropping seasons – Kharif and Rabi. Kharif crop is harvested between October to November every year whereby paddy, cotton, sugarcane, maize, groundnut, pulses and sesame are majorly harvested. Crops grown in Rabi season are harvested from March to April each year whereby the major crops being harvested include wheat and rapeseed and mustard.

- Odisha is the **fourth largest producers of rice in the country with 2723 kg/ha.** Th production of rice and maize in the state has increased by 12.7% and 13.5% respectively over the previous year (FY 2019-20) (Economic and Statistical Organisation, Government of Odisha 2022).
- Odisha also ranks **first in the production of sweet potato and paddy straw mushroom within the country**.

The sector continues to be the primary source of livelihood for a majority of the population considering the fact that it employs around 56% of the state's population under various core and allied activities (Springer 2021).

- In order to improve the economic condition of workforce in agriculture sector (stressing on enhancing farmer's income through non-farm activities), the **state has increased its expenditure in agriculture and allied activities from INR 10.897 Cr in 2021-22 to INR 12,128 Cr in 2022-23**.
- **In FY22, the state allocated 7.4% of its total budget towards agriculture and allied activities** which higher than the average allocation for agriculture by states (6.3%) (PRS 2022).

Key sources of energy consumption in agriculture sector

- The **major consumption of energy** in agriculture sector in general is due to **irrigation pumps, tractors, other farm mechanization equipment and post harvesting equipment**.
- Penetration of farm mechanization equipment in Odisha is improving gradually. Due to rapid growth and scope for mechanization in Odisha, recently a good number of manufacturers have come forward for manufacturing agricultural equipment in the state.
- Over the years, the Farm Mechanisation has significantly improved the productivity of crops and the efficiency of farming by attaining more output with minimal labour, reducing post-harvest losses, and saving time & costs.

The government facilitates agricultural lending and offers financial help in the form of subsidies to farmers in order to encourage them to use more advanced farm technology and equipment. With the provision of subsidies, the State is undertaking programmes to encourage the use of agricultural tools, machinery, and diesel pump sets. During 2018-19, around 1793 tractors and 9599 power-tillers were supplied to the farmers under various farm mechanization schemes (Directorate of Agriculture and Farmers Welfare, Odisha 2022). However, supply of power and small size of land holdings are challenges for widespread adoption of farm mechanization in the state. In 2020, Government of Odisha has initiated a unique scheme BALARAM (Bhoomihina Agriculturist Loan and Resources Augmentation Model) for financing sharecroppers by forming JLGs (Joint Liability Groups). This is a unique model among all states for welfare of the farmers cultivating others' land on lease basis.

Most of the energy consumption in agriculture sector of Odisha is in irrigation pumps and tractors. **As of FY2022, 1.54 lakh tractors are being used for cultivation** (almost all running on diesel).

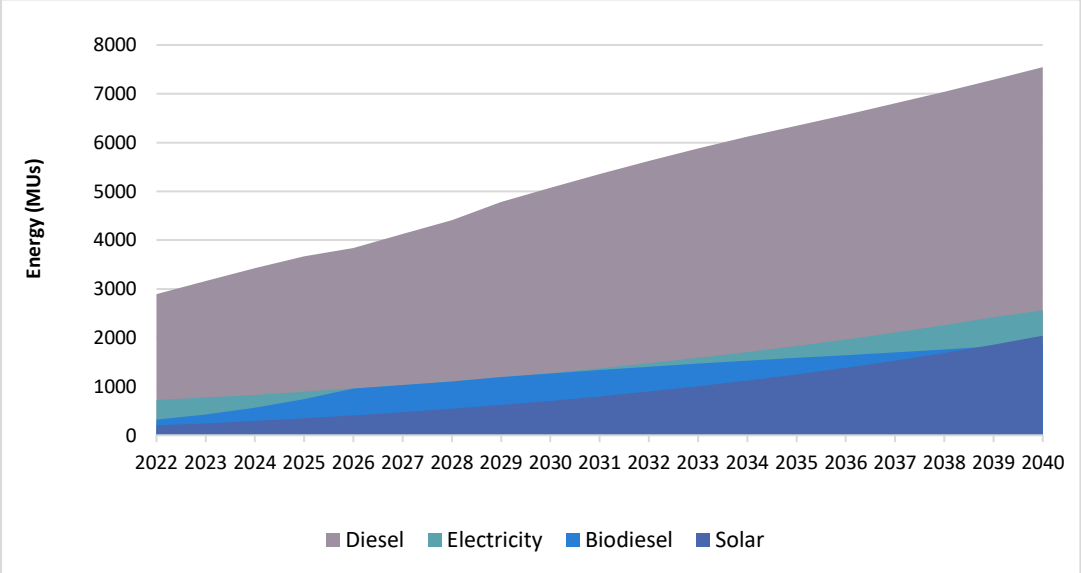
In case of pumps:

- The share of **electric pumps is highest contributing to 51% of the total base** of the pump set installed in the state
- **Diesel pumps' share is 35%** of the total base of the pump set installed in the state
- **Solar pumps' share is 14%** of the total base of the pump set installed in the state

Energy Consumption of the Sector

The share in total power consumption by agriculture in 2020-21 stood at 3.9% in Odisha compared to national average of 20.5% indicating the scope for increasing power consumption for higher levels of irrigation, farm mechanization etc to increase agricultural productivity. The major source of energy consumption is the state is due to the pump states and tractors. The penetration of diesel pumps has reduced from 69.64% in FY 2011-12 and there has been a gradual shift in the fuel mix for pumps from diesel to electric and solar. Further, the state has 1.54 lakh registered tractors in the state engaged in the agriculture sector and almost all of these tractors (99.85%) run exclusively on diesel.

In the baseline scenario, the total energy demand for agricultural sector grows at the CAGR rate of 7.02% between 2022 and 2040. In absolute terms, the total energy demand is poised to increase from 4.13 TWh in 2022 to 14.03 TWh in 2040. Major energy consumption in the sector takes place through the farming activities which are mostly driven by the tractors, power tillers, harvesters etc. Oil is the major fuel source for running this farm equipment. Use of solar pumps in the state is expected to steadily increase from 209,475 (nos.) in 2022 to 1,169,498 (nos.) in 2040. The figure below presents the projected energy demand of the agriculture sector by fuel and



technology type.

Figure 28: Energy demand for Agricultural sector in the baseline scenario (Pumping and Machinery) in Odisha

Existing initiatives undertaken in the State

There are multiple interventions being undertaken in the state which have an impact in optimizing the energy consumption in the sector:

Centrally Sponsored Schemes:

1. Rashstriya Krishi Vikas Yojana (RKVY)

In 2007, the government launched the RKVY scheme which enables states to select their own agricultural and allied sector development initiatives in accordance with the district/state agriculture plan, supporting the holistic development of these sectors. Under this scheme, the funds are disbursed to the State Governments/UTs on the basis of projects accepted in the State Level Sanctioning Committee Meeting (SLSC), which is the authorised body to approve projects under the programme and is chaired by the Chief Secretary of the concerned State. In Odisha, allocation of funds under normal RKVY and sub-scheme (Bringing Green Revolution to Eastern India (BGREI), CDP, RPS, etc.) for year 2019-20 was around INR 136.29 crore and INR 71.55 crore respectively.

2. Intensification of Farm Mechanization - Sub-mission on agriculture mechanisation (SMAM)

The overall objective of the SMAM 2020-21 scheme was to expand the use of farm mechanisation to small and marginal farmers as well as to areas where farm power is scarce. It also aimed to establish centres for high-tech and expensive farm equipment and raise awareness among stakeholders through capacity-building and demonstration efforts. In Odisha, around 46,302 cumulative number of agricultural machineries were distributed under this scheme along with the establishment of 1,603 custom hiring centres CHC. More than 128 farm machinery banks were also established along with seven high-tech hubs. Odisha in its FY 2023-24 budget proposed around INR 388 crore towards subsidy for capital investment for the establishment of commercial agri-enterprises & for popularization of agricultural implements and diesel pump sets.

3. Pradhan Mantri Krishi Sinchai Yojana (PMKSY)

PMKSY is a scheme developed by the Government of India to enhance the physical access of water on the farm and expand cultivable area under assured irrigation, improve farm water use efficiency to reduce wastage and increase availability both in duration and extent, enhance the adoption of precision - irrigation and other water saving technologies (More crop per drop). The major objective of PMKSY is to achieve convergence of investments in irrigation at the field level, expand cultivable area under assured irrigation, improve on-farm water use efficiency to reduce wastage of water, enhance the adoption of precision-irrigation and other water saving technologies (More crop per drop), enhance recharge of aquifers and introduce sustainable water conservation practices by exploring the feasibility of reusing treated municipal waste water for peri-urban agriculture and attract greater private investment in precision irrigation system. In 2021-22, around 30.33 thousand hectors land in Odisha benefited from this scheme.

4. National Food Security Mission (NFSM)

The National Food Security Mission (NFSM) is a centrally funded scheme which was launched in 2007 based on the recommendations of the National Development Council (NDC) Sub-Committee on Agriculture. The commission emphasized the need to improve agricultural extension services, technology transfer and decentralized planning. The main focus areas of the mission include sustainable increase in production of target crops through area expansion and productivity improvement, restore soil fertility and productivity on a farm-by-farm basis and to increase in farm level net income. In FY 2022-23, around INR 8.12 crores has been sanctioned as Grants-in-Aid general to the State Government of Odisha under Food and Nutrition Security.

5. Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan (PM-KUSUM)

Launched in March 2019 by MNRE, the Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan (PM-KUSUM) is primarily aimed at promoting the use of solar energy in the agricultural sector. This is expected to be carried out by installing new solar pumps, setting up grid-connected ground-mounted solar power plants and extensively solarizing the existing pumps. Under the scheme, a total of 30.8 GW of solar power capacity under all three components combined is expected to be developed by 2022 with revised central financial support of INR 34,422 crores.

Under component A, the total sanctioned solar capacity for Odisha is 500 MW. Under component B, so far, 1223 off-grid (standalone) solar pumps have been installed out of the targeted 5471 nos.

State Sector Schemes:

6. Krushak Assistance for Livelihood and Income Augmentation (KALIA)

KALIA is a direct income transfer programme that was introduced in the year 2018 to help farm households with the cost of inputs including seeds, fertiliser, pesticides, labour, and other investments. The government proposed to offer monetary support under the programme wherein each landless agricultural household will be given support for finding alternate sources of income through farming and related endeavours like raising miniature goats, mini-layers, ducks, fishing, growing mushrooms, beekeeping, etc. Small and marginal farmers received a financial assistance of INR 25,000 over five seasons per farm family so that farmers can buy inputs like seeds, fertiliser, pesticides, and use assistance for labour and other, and each landless agricultural household receives a financial assistance of INR 12,500 for agriculturally related activities. As of year 2020, there were 48,65,053 total beneficiaries of this scheme.

7. Bhoomihina Agriculturist Loan and Resources Augmentation Model (BALARAM)

In partnership with NABARD, the programme enables Lessee cultivators and sharecroppers access to bank finance as well as the formation of Joint Liability Groups (JLGs) as a strategic intervention, reducing their reliance on informal credit sources. The banks finance crop loans of Rs. 1.60 lakh per group. This is a unique model among all states for welfare of the farmers cultivating others' land on lease basis. Under the scheme more than 10,000 JLG groups has been formed that involves more than 36,000 farmers.

8. Mukhyamantri Krushi Udyog Yojana (MKUY)

In 2018, MKUY was introduced to encourage the establishment of commercial Agri-enterprises. Under the State Agricultural Policy, Agro-Entrepreneurs are given capital investment subsidies for setting up commercial agri-enterprises. Financial aid such as 40% of fixed capital investment for general entrepreneurs up to a maximum of INR 50 lakhs. Under these scheme more than 7,515 agricultural enterprises has been supported by the state government incentives.

9. Soura Jalanidhi

The Government of Odisha is encouraging the use of solar pumps for irrigation in an effort to boost the state's crop production and irrigation potential. The scheme aims to provide around 5000 solar pumps to the farmers with 90% subsidy. The state's Science & Technology Department's Odisha Renewable Energy Development Agency (OREDA) is running this programme. The scheme offers financial assistance for installation of pump in his/her premises and gives priority to the districts of the state that are not covered by power grid. In FY2019-20, under Sourajalanidhi scheme 230 solar pumps (0.5 HP) were distributed to the farmers having a minimum of 0.5-acre cultivable land. Additionally, in its FY 2023-24 budget estimates, Odisha has proposed around INR 250 crore under Soura Jalanidhi for bringing more area under assured irrigation.

10. SAMRUDHI Agriculture Policy

Odisha's SAMRUDHI Agriculture Policy, 2020 promotes the use of renewable energy in the agricultural sector. It developed five-year plans and comprehensive strategies to build on Odisha's inherent strengths, as well as ways to make the best use of available opportunities and resources. The policy states that solar-powered irrigation pumps

will be encouraged to meet farm energy requirements and efforts will also be made to connect the solar panels to the grid.

Additionally, Government of Odisha has developed a single window unified gateway for agrarian management **(GO-SUGAM)** portal.

Description of Aggressive Scenario for sector

The total energy demand for agricultural sector is expected to grow at the CAGR rate of 3.57% between 2022 and 2040. In absolute terms, the total energy demand will increase from 4.13 TWh in 2022 to 7.78 TWh in 2040. Major energy consumption in the sector takes place through the farming activities which are mostly driven by the tractors, pumps, power tillers, harvesters, etc. Oil is the major fuel source for running this farm equipment.

Use of solar energy for agriculture in the state is expected to steadily increase at a CAGR of 8.6% from 0.2 TWh in 2022 to 0.88 TWh in 2040 on account of deployment under PM KUSUM scheme and other state-level initiatives. On the other hand, the demand of diesel is decreasing gradually at a CAGR of -6.5% from 0.25 Mtoe in 2022 to 0.07 Mtoe in 2040 indicating a huge reduction in consumption by 2040. Penetration of solar and electric pumps under this scenario is taken at a 50:50 ratio. The figure below presents the projected energy demand of the agriculture sector by fuel and technology type:

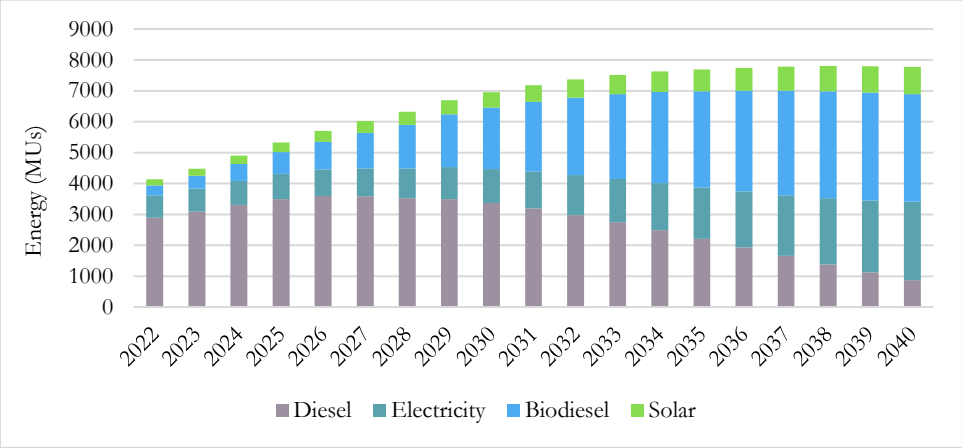


Figure 29: Energy demand for Agricultural (Pumping and Machinery) sector in Odisha

Description of Decarbonization Scenario for sector

The total energy demand for agricultural sector is expected to grow at the CAGR rate of 2.77% between 2022 and 2040. In absolute terms, the total energy demand will increase from 4.13 TWh in 2022 to 6.76 TWh in 2040. Major energy consumption in the sector takes place through the farming activities which are mostly driven by the tractors, power tillers, harvesters, pumps, etc. Electricity is the major fuel source for running this farm equipment.

Use of solar energy in the state for agriculture is expected to steadily increase at a CAGR of 12.62% from 0.2 TWh in 2022 to 1.70 TWh in 2040 on account of deployment under PM KUSUM scheme and other state-level initiatives. On the other hand, the demand of diesel for agricultural activities decreases from 2.89 TWh in 2022 to zero TWh in 2040 indicating a complete phase out by 2040. This is mainly due to the gradual decrease in the use of diesel pumps. The use of diesel pumps is decreasing gradually from 520.364 (nos.) in 2022 to zero in 2040. Penetration of electric and solar pumps under this scenario is taken at an 80:20 ratio whereby 80% solar pumps shall be deployed and 20% electric pumps. The figure below presents the projected energy demand of the agriculture sector by fuel and technology type:

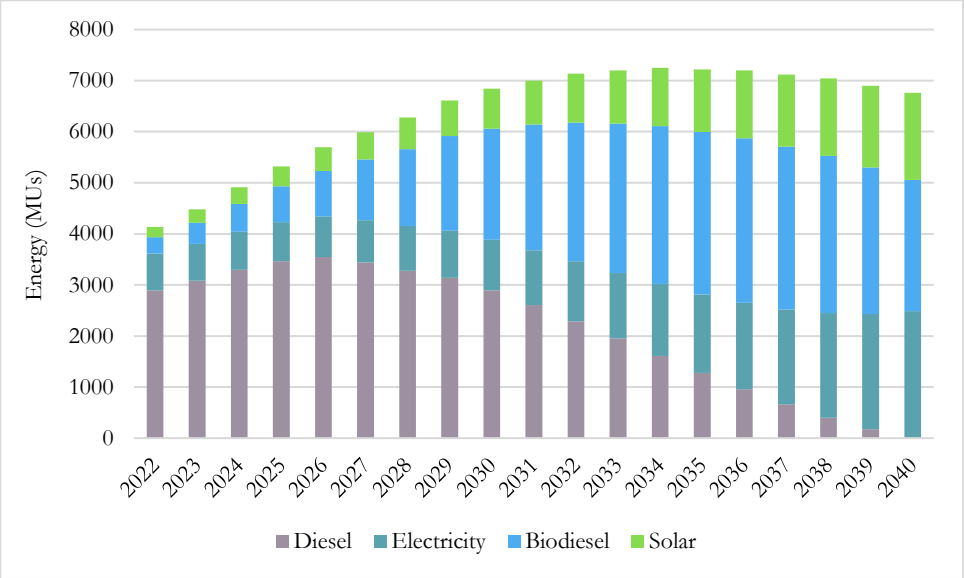


Figure 30: Energy demand for Agricultural (Pumping and Machinery) sector in Odisha

Sectoral Vision

In the baseline scenario, agriculture sector accounts for ~1.6% of the total energy consumption of the state in 2040. Although agriculture sector witnesses a robust growth from 2022 to 2040, the energy intensity in the sector is low due to limited farm mechanization. However, there is a large scope for energy efficiency and enhancing energy conservation which can have a positive impact on enhancing farmers' income, improve farm productivity as well as lead to resource conservation. The existing policies and their corresponding targets can help achieve the intended energy goal for the state.

Vision:

State shall ensure 100% utilization of the available local resources by 2040 for fulfilling the energy needs of the agriculture sector alongside reducing the costs involved in fuel consumption for irrigation, harvesting and other farm activities. State shall also promote doubling farmers' income by 2030 by providing options of reducing fossil fuel consumption and replacing the same with renewable energy by providing support for off-grid solar installation.

Action Plan

a) **Objective:** State shall replace 80% of energy requirement for pumping from diesel to solar by 2040 and complete phasing out of diesel pumps by 2040

Activity:

A.1: State shall increase penetration of solar pumps by developing adequate financing mechanisms

A.2: State shall create market mechanisms as well as generate awareness to increase uptake of energy efficient pumps

A.3: State shall explore the potential of developing decentralised solar PV especially agro PV and vertical solar PV on the farmlands.

b) **Objective:** State shall improve energy efficiency and increase penetration of renewables in post-harvest activities

Activity:

B.1: State shall increase penetration of solar power micro cold storage

B.2: State shall increase private sector participation in establishing energy efficient post-harvest processes and infrastructure

B.3: State shall facilitate availability of e-tractors

Decarbonization of the agriculture sector could have substantial environmental benefits for the state of Odisha, in terms of reduction in the GHG emissions:

Table 21: Summary of recommendations for agriculture sector

S.No.	Sub-sector	Recommendation Category	Recommendation	Types of scenario	Time Period	Type of intervention	Implementing Agency
1.	**Agriculture Sector**	Increase penetration of energy efficiency and solar power in value chain	Increasing productivity of farmers using renewable energy (including solar, CBG, etc.)	Aggressive; Decarbonization	Short to Long	Technical	OREDA, Department of Agriculture, GRIDCO
2.			Distribution of energy efficient pumps to replace existing inefficient electric pumps	Aggressive; Decarbonization	Short to Medium	Technical	OREDA, GRIDCO
3.			Increase construction of energy efficient cold storage working on solar power	Low emission; Decarbonization	Short to Long	Technical	OREDA, SDA
4.			Develop co-operatives to provide financial support for procurement of solar pumps and energy efficient pumps by farmers	Aggressive; Decarbonization	Short to Medium	Financial	DoP, Department of Agriculture
5.			Promote installations under PM KUSUM scheme in the state	Aggressive; Decarbonization	Short	Capacity building / awareness generation	OREDA
6.			Facilitation of e-tractors for farmers	Decarbonization	Short to Long	Technical	OREDA, State Transport Authority
7.			Promotion of irrigation (micro irrigation) to increase utilization of untapped ground water potential	Aggressive; Decarbonization	Short to Long	Awareness generation	Department of Agriculture, OREDA
8.		Capacity building / Awareness creation	Undertake awareness Programme for disseminating benefits of energy efficient pumping and irrigation systems as well as solar powered pumps to farmers through co-operatives, gram panchayats etc.	Aggressive; Decarbonization	Short to Medium	Awareness generation	OREDA, Department of Agriculture
9.			Continue promotion of crop diversification	Aggressive; Decarbonization	Short to Long	Awareness generation	Department of Agriculture

Recommendations for Agriculture Sector

Provided below are details of the action plans defined for the state in the above table:

1. Increasing productivity of farmers using renewable energy

Use of renewable energy in the agricultural sector in Odisha could help farmers to increase agricultural productivity as well as to earn additional income by value addition to their produces (e.g., controlled drying of fruits and vegetables, off-seasonal production of fruits and vegetables with round-the-year irrigation, longer shelf life of products through the aid of solar cold storages, etc.). A high level of integration of RE into an agricultural process can lead to high efficiencies, low environmental impact, and low production costs. Energy in agriculture value chain is consumed in the following manner:

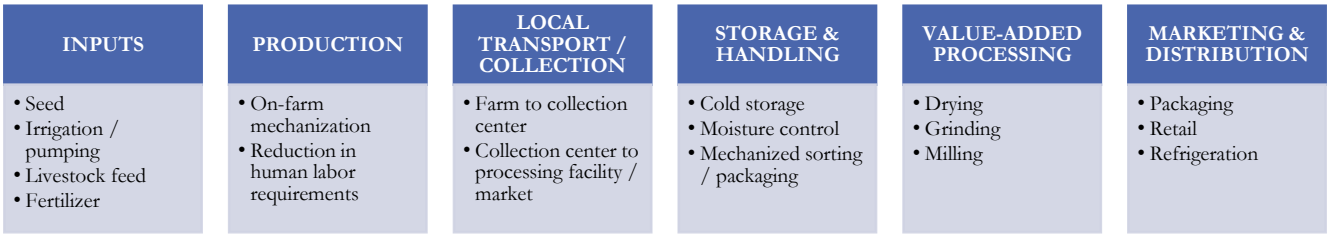


Figure 31: Energy consumption in agriculture value chain

At the input stage, fertilizer and pesticide dispensing device powered by solar energy could be a game-changer for Odisha. Such a device will reduce the labour of farmers who have to manually spray pesticides / fertilizers or use fossil-fuel based machines for the same. This technology is already commercially available in India and such a device can work with both liquid and solid fertilizers. Initially, a pilot can be funded by OREDA to assess the feasibility of such devices for the farmers. In case of a successful pilot, promotion of such devices can be taken up at a large scale in the state. Next, is solar irrigation pumps, the use case and the action plan for which has been detailed out in the subsequent action plans.

Additionally, **the utilization of biomass and biodiesel** for farm mechanization in Odisha has the potential to be truly game-changing for the agricultural sector. By harnessing the abundant biomass resources available (4.5 million tonnes) in the region, such as crop residues, agro-waste, and animal manure, farmers can produce renewable energy in the form of biodiesel. This biodiesel can then be used to power farm machinery, reducing reliance on fossil fuels and mitigating the environmental impact of agriculture. The adoption of biomass-based energy solutions can lead to increased efficiency, cost savings, and reduced carbon emissions. Moreover, the local production of biodiesel can create new income streams for farmers, fostering rural development and improving livelihoods. By embracing this sustainable approach to farm mechanization, Odisha can pave the way for a greener, more resilient agricultural sector, ensuring a better future for both farmers and the environment.

At the production stage, on-farm mechanization powered by RE can be explored. Facilitation of e-tractors to run on-farm machinery has been explored in the subsequent action plans. In addition to this, bio-CNG / CBG based tractors also present a good use case for the state. As per the statement released by Union Minister Road Transport and Highways of India, tractors running on bio-CNG could help cut down annual fuel cost for a user by around 55%. They do not emit any noxious fumes and are 85% less pollution compared to a diesel-run tractor. The conventional diesel tractors can be converted to bio-CNG. Since the commercial viability of such tractors is under evaluation, OREDA could undertake a pilot study to assess the feasibility of such tractors in Odisha.

At the local transportation and storage stages, the inclusion of e-reefer trucks for refrigeration and solar cold storages is pertinent for Odisha to reduce its post-harvest losses at the pre-cooling stage. The action plan for development and expansion of solar cold storages has been explained in the subsequent sectoral action plans. For e-reefer trucks, Odisha can support the R&D on improved manufacturing techniques for EV/EV components.

At the processing stage, Odisha needs to carry out promotion of decentralized solar-powered processing machines to decrease the load on the grid. These machines can be powered using solar-based micro-grids. The need of the hour is to provide incentives to the farmers to adopt such solutions to fulfil their on-farm electricity needs. The state government could provide early-stage support indirectly through loan guarantees via commercial lenders, or by direct support mechanisms, such as capex subsidy. In terms of a direct subsidy support to the developer, an arrangement similar to PM KUSUM can be thought of. State government could provide 30% subsidy on the capex on per MW basis. Synergies could also be drawn with the National Agriculture Infra Financing Facility (Department of Agriculture & Farmers Welfare 2022). The state government could sign an MOU with the state commercial banks, Cooperative Banks, RRBs and Small Finance Banks for provision of funding under the AIF scheme to farmers for funding Agriculture Infrastructure Projects at farm-gate & aggregation points. This shall boost their confidence in adopting such innovative solutions aimed at improving their agriculture productivity.

2. Distribution of energy efficient pumps to replace existing inefficient electric pumps

Bureau of Energy Efficiency (BEE) have made significant efforts towards mandating the use of EE pumps in agriculture by involving state regulatory commissions. In consequent to the efforts made by BEE, state governments including Odisha have made it mandatory to use star labelled Energy Efficient Pumps sets (EEPS) for all the new pumps set connections. They had undertaken the replacement of agricultural pumps in 10 states across 11 discoms, wherein inefficient agricultural pump sets were being replaced with BEE 5 star-rated energy efficient pump sets. Farmers were offered a zero-cost energy efficient pump set (EEPS), and a long-term partnership with EESL under the ESCO model. The initial cost of installing pumps was undertaken by EESL and it recovered the EEPS cost over a mutually agreed period of time by monetizing energy savings. EESL also offered free repair maintenance during the 5-year project duration, further incentivizing farmers to adopt newer and more efficient models.

Odisha can work with BEE to expand the program where it would work on a similar model. Based on the information developed in the Odisha Energy model, the following investment potential is present in replacement of energy efficient pumps in Odisha in Low emission and decarbonisation scenarios:

Aggressive scenario:

Table 22: Investment requirement for energy efficient pumps in aggressive scenario

Term	Total no. of Pumps	Target Penetration	Numbers	Net Cost (INR Crore)	Power savings (MU/yr)	Cost savings/yr (INR Crore)	Payback period (in year)
Short	1,440,389	10%	144039	396	11	16	24.58
Medium	1,333,419	40%	533367	1467	40	60	24.58
Long	1,017,345	50%	508672	1399	38	57	24.58

Decarbonisation scenario:

Table 23: Investment requirement for energy efficient pumps in decarbonization scenario

Term	Total no. of Pumps	Target Penetration	Numbers	Net Cost (INR Crore)	Power savings (MU/yr)	Cost savings/yr (INR Crore)	Payback period (in year)
Short	1,124,350	30%	337305	928	25	38	24.58
Medium	1,210,169	50%	605085	1664	45	68	24.58
Long	1,220,207	65%	793135	2181	59	89	24.58

Assumptions:

i. Total no. of electric pumps added in each term is taken from Odisha Energy Model (Odisha Energy Model Analysis, 2022)
ii. Annual hours of usage of pumps is 1000 hours (CEEW 2021)
iii. Unit power cost for agricultural consumers (irrigation pumping) is INR 1.50/unit (OERC 2023)
iv. Cost of energy efficient 5 HP 5 star pump is INR 27,500 (industrybuying 2022)
v. Energy savings by operating energy efficient pumps for 1 hour is 0.746 unit

1. Develop co-operatives to provide financial support for procurement of solar pumps and energy efficient pumps by farmers

Penetration of solar pumps can be increased by providing loans at less-than-market rates through co-operatives and gram panchayats. The co-operatives shall be adequately supported by civil society organizations (CSOs) mobilized by the State Government. A low annual interest rate of, let's say, 2% could be charged for the loan. The CSOs shall be provided with technical know-how to provide technical assistance to farmers willing to opt for solar pumps and educate them about the operational.

Based on the penetration of solar pumps obtained from Odisha Energy Model, the following investment potential has been derived for Low emission and decarbonisation scenarios:

Aggressive scenario:

Table 24: Investment requirement for solar pumps in aggressive scenario

Term	Total no. of Pumps	Target penetration	Target (in nos.)	Cost of solar pumps (INR Cr)	Annual interest (INR Cr)	Annual diesel savings (INR Cr)	Actual Cost savings (INR Cr)	Payback period (in years)
Short	1,440,389	20%	289,945	10,148	203	2,792	2,081	4.87
Medium	1,333,419	30%	401,178	14,041	281	3,863	2,880	4.87
Long	1,017,345	50%	508,672	16,652	333	4,581	3,415	4.87

Decarbonisation scenario:

Table 25: Investment requirement for solar pumps in decarbonisation scenario

Term	Total no. of Pumps	Target penetration	Target (In nos.)	Cost of solar pumps (INR Cr)	Annual interest (INR Cr)	Annual diesel savings (INR Cr)	Actual Cost savings (INR Cr)	Payback period (in years)
Short	1,124,350	30%	369,352	12927	259	3556	2651	4.88
Medium	1,210,169	50%	627,697	21969	439	6043	4506	4.88
Long	1,220,207	80%	976,166	28970	579	7969	5941	4.88

Assumptions:

i. Total no. of solar pumps added in each term is taken from Odisha Energy Model (Odisha Energy Model Analysis, 2022)
ii. Cost of 5 HP solar pump is INR 3,50,000 as per prevalent market standards
iii. Unit power cost for agricultural consumers (irrigation pumping) is INR 1.50/unit (OERC 2023)
iv. Annual hours of usage of pumps is 1000 hours (CEEW 2021)
v. Operating cost of solar pump is 5% of capital cost (Niti Aayog 2017)
vi. Density of diesel is 0.832 kg/litre
vii. Annual Fuel usage for a diesel pump is 1000 litres (novo3D 2023)
viii. Cost of diesel is INR 96.28 /litre
ix. Interest rate for loan is 2% (Bank of Baroda n.d.)

In case of any farmer wants to opt for energy efficient pumps, over and above the ones who are getting served by the energy efficient pump program described above, they can avail this loan as well. The modalities for disbursal will be same.

2. Increase construction of energy efficient cold storage working on solar power

Odisha is yet to exploit the potential of solar powered cold storage facilities in the state. The state has expressed a need for modernisation/upgradation of existing refrigeration systems. Firstly, replacement of existing compressors with new energy efficient compressors with water cooled head cooling arrangement and oil cooling arrangement could be explored; however, to decide the refrigeration capacity of the compressor, the effectiveness of insulation needs to be checked. Secondly, there is a need to commission solar-based cold storages in the future along with retrofitting existing cold storage units with solar power. While solar power in can suffice the power requirements for micro cold storages, larger cold storage units cannot be powered by solar power alone. In such a case, an on-grid solar system can be used to partially provide for the power requirements.

A conventional cold storage has a designed refrigeration load of 120-150 W/m2. With the application of modern technology in energy efficiency for cold storage, this load can come down to 75 W/m2 and in case of larger stores, a load of 50 W/m2 is also achievable. In order to achieve energy efficiency in cold storages, some of the activities that can be undertaken are as follows:

a) Installation of variable speed fans for condensers and room fans. 50% speed equates to an 85% energy reduction
b) Improving insulation of cold storage by installing Polyisocyanurate (PIR) cold store panels
c) Vertical Park dock levellers that do not penetrate the cold envelope when not in use (Alapont 2023)
d) Hi-speed bi-parting cold-store doors eliminating need to duplicate door with high speed air curtain
e) Use of energy management systems
f) Energy saving light fittings i.e., installation of LED lights.

3. Promote installations under PM KUSUM scheme in the state

To improve, expand and speed-up the roll-out of the PM KUSUM scheme, it is imperative that an extensive promotion and outreach strategy is adopted to encourage farmer participation. It is paramount to disseminate relevant information to the farmers including information on implementing models, means of accessing finance to cover their capital expenditure (as permitted in the scheme guidelines) and to ensure adoption of sustainable farming practices such as adoption of drip or sprinkler irrigation. Appropriate communication will support in rapid rolling out and scaling up of PM KUSUM. MNRE, at the central level, is already developing a dedicated portal for promotion and hosting achievements under the PM KUSUM scheme. Some SNAs have also taken the initiative to create awareness about the contours of the scheme through dedicated portals. Some of these states include Rajasthan, Tripura, Gujarat, etc. Learnings on developing the content of the portal could be taken from these states and MNRE.

Odisha could consider designing a State Information Portal for PM KUSUM scheme. It is considered essential by the farmers to acquire details about the scheme components before deciding to participate in it. Farmers tend to lack awareness around who the implementing agency is, what are their available capacity options, where can they avail the loan from, what documentation is required to apply under any scheme component, etc. As such, having state information portals providing information on all the above mentioned parameters shall aid the farmers in making informative decisions with respect to participation in the scheme.

The portals could be designed in a manner that provides the detailed scheme guidelines followed by the contact details of the State Implementing Agencies. As a value addition, frequently asked questions (FAQs) could be designed for each of the scheme components to answer the recurring questions of the farmers /proposed scheme beneficiaries, etc. These FAQs could be divided into categories such as:

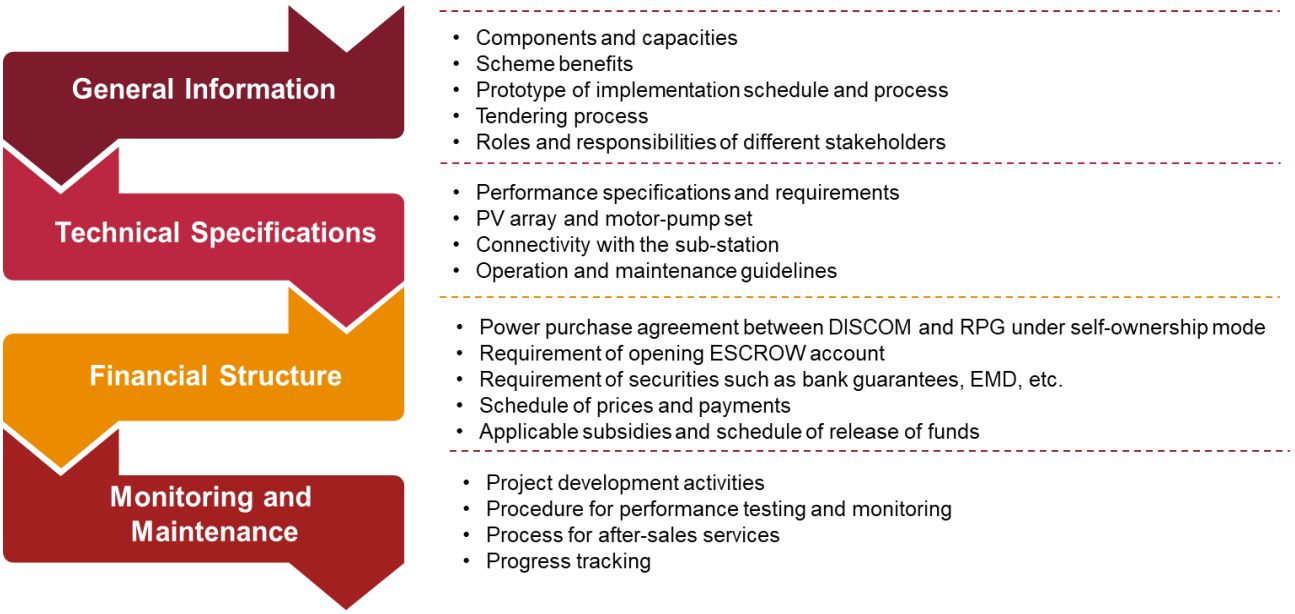


Figure 32: Categories for FAQs

The state government also needs to consider bringing some part of the net sown area for development of solar PV projects. The most suited option in this case is the development of agro PV on farmlands. Additionally, unlike a typical solar farm where the solar panels are tightly installed to maximize land use, in agro PV, the solar panels can be installed with sufficient clearance for easy movement of the farmers and farm equipment. This can aid Odisha in achieving the Component A target under the PM KUSUM scheme. This shall also aid in water conservation on the farmland. Internationally, a recent study in agro PV spread across 6 acres of land in Oregon State University, Corvallis campus in the US shows that the water conversation improved by 328% due to solar panels. Agro PV also offers to generate additional income for the farmer. A grid-tied solar panel enables farmers to sell the excessively generated electricity to utility companies

4. Undertake awareness programmes for disseminating benefits of energy efficient pumping and irrigation systems as well as solar powered pumps to farmers through co-operatives, gram panchayats etc.

Energy efficient pumps and solar pumps provide substantial energy savings and cost benefits. Users should be made aware of the benefit of using the pumps over existing electric/diesel pumps through targeted outreach program. The effective medium for reaching out to individual farmers is through farmers' co-operatives, where workshops can be arranged to disseminate the information.

5. Promotion of micro irrigation to increase utilization of untapped ground water potential

Odisha has vast ground water potential which is available for exploration. So far, about 28% of ground water resources have been tapped for irrigation purpose. Thus, there is scope for further exploration of ground water resources up to 70% of the total recharge per year, which will go a long way in expanding area under irrigated agriculture. Realizing the need to increase the irrigation potential and to utilize untapped ground water potential in the state, the farmers are encouraged to go for own captive irrigation (Bore well & Shallow Tube well) projects under the State Agriculture Policy. Development of irrigation infrastructure is crucial to address the vulnerabilities posed by changes in rainfall patterns in the state. Additionally, emphasis on micro irrigation practices can be given. This can give irrigation efficiency as high as 80% in case of drip irrigation and 60-70% in case of sprinkler irrigation as compared to normal irrigation efficiency of 30-40%. Some of the other advantages of the micro irrigation practices include:

- Due to improper water supply, fertilizers and nutrients cannot reach the roots of every plant. Drip Irrigation system helps it to reach effectively.
- Sprinkler irrigation is suitable for all types of field condition and ensures uniform distribution of water with high efficiency.

The state government has introduced the "Soura Jalanidhi" Scheme to ensure irrigation facilities in remote and drought prone areas. Such initiatives need to continuously be undertaken to promote utilization of ground water. Significant capacity building also needs to be undertaken to educate farmers on the benefits of different irrigation practices. These sessions could be delivered with the aid of SHGs and FPOs that the farmers are a part of.

6. Continue promotion of crop diversification and mechanised cultivation

Through crop diversification, the state aims to divert area under kharif rice towards less water consuming and high value crops like pulses, cotton, maize, oilseeds etc. The Government has been continuously taking initiatives for diversification of crops with emphasis on these high value crops through various developmental schemes like National Food Security Mission (NFSM), Integrated Farming System (IFS), Intensive Agriculture Programme (IAP), and crop-oriented programme for pulses and oilseeds among others. These efforts have played an important role in the diversification of the crop sector in recent years. Furthermore, as part of 5T initiatives of the Government, there has been a special focus on crop diversification by targeting fallow areas.

To motivate the farmers to adopt crop diversification, firstly, provisioning of subsidized seeds and other inputs for these crops is required by the state government. Due to various seed multiplication programmes of the state government the Seed Replacement Rate (SRR) in different crops has been increasing. During 2020-21 the SRR for Paddy was about 26% and for the high value crops like maize, cotton, sunflower and groundnut the SRR was 60.46%, 62.33%, 21.74% and 12.01% respectively.

Apart from this, the state government could consider providing financial assistance to farmers on various machinery and equipment needed for mechanized cultivation. Success stories of crop diversification and farm mechanisation are likely to provide compelling evidence for the farmers to move away from water guzzling and labour intensive crops such as paddy. Further, more sustained focus should be given on training of trainers (TOT) for creating awareness among the farmers around crop diversification and switching of area from water gushing crops to less water consuming crops.

7. Facilitation of e-tractors for farmers

With the cost of diesel having crossed INR 96 per litre in Odisha, the cost of farm produce has risen significantly over the last several years. Electric tractors, with their relatively economical costs, can become the most suited replacement to traditional diesel-driven tractors in the state. Besides, e-tractors will also result in lower CO2 emissions, promote green farming, and will take a step towards a circular economy.

For promoting the adoption of e-tractors in the state, formulisation of the final Odisha EV Policy is a pre-requisite. The policy should enable the development of a Centre of Excellence (CoE) in e-mobility in partnership with an academic partner. CoE shall encourage R&D for development of electric tractors in collaboration with industry players. The policy should also provide special concessions for e-tractor manufacturing in the state. Under the policy, the state should encourage proposals from the industry to set up dedicated anchor units to manufacture e-tractors in the state and provide additional incentives over and above those applicable for anchor units of other EVs.

Odisha government recently organized **Krushi Odisha 2023** jointly with FICCI in association with Agriculture and Farmer's Empowerment Department with an aim to update the farmers with the latest technology for farming and mechanization of production. During this event, Sonalika Tractors launched its technologically advanced e-tractor model named "Sonalika Tiger Electric" which is specially designed in Europe and offers appreciable power, exceptional performance, and efficiency. It is aimed to cater to the ever-evolving needs of new-age Odisha Farmers.

The adoption of electric tractors has the potential to revolutionize the agriculture sector by decarbonizing operations and promoting sustainability. By eliminating the use of fossil fuels, electric tractors significantly reduce greenhouse gas emissions and air pollution associated with traditional diesel-powered machinery. Moreover, the renewable energy sources powering electric tractors, such as solar, further enhance their sustainability, making them a key driver in transitioning towards a greener and more environmentally friendly agricultural system.

Investment Required

The following table provides the investment required in terms of unit cost of preferred equipment and the number of units requiring such equipment in 2040:

Aggressive scenario:

Table 26: Investment requirement agriculture sector in aggressive scenario

S.No.	Particulars	Average cost per unit (INR)	No. of units by 2040	Total Cost in INR Crores
1.	Solar pumps	3,27,362	508,672	16,652
2.	On-grid electric pumps	27,503	508,672	1399

Decarbonisation scenario:

Table 27: Investment requirement agriculture sector in decarbonization scenario

S.No.	Particulars	Average cost per unit (INR)	No. of units by 2040	Total Cost in INR Crores
1.	Solar pumps	2,96,773	976,166	28,970
2.	On-grid electric pumps	27,498	793,135	2181

Assumptions:

1. Number of units derived from total energy consumption for energy projections in 2040.
2. Rating for solar pump and on-grid electric pump considered as 5 HP and 5 HP and average annual utilization is considered as 1000 hours.

6.2. Fisheries Sector

Overview of Sector

Within the agriculture sector, the fishery subsector has been considered a sunrise sector by the state government as it has shown a significant increase in the last two decades with an **average growth of 11.2% in the last 10 years** (Economic and Statistical Organisation, Government of Odisha 2022). Fisheries and aquaculture are also playing a major role in multiplying farmers' incomes, enhancing livelihoods, creating gainful employment, providing nutritional security, and contributing to export earnings in Odisha. The Government of Odisha has kept a high priority on the fisheries sector and placed the fisheries and aquaculture sector as one of the growth propellers for over 15.89 lakh fishermen including farmers, women SHGs youths, and entrepreneurs.

In terms of **fish production:**

- Odisha ranks 4th in India with 8.73 lakh metric tons of fish produced during 2020-21 contributing to 2.33% of the state economy.
- In 2021-22, fish production has increased by 13.4% to reach 990 thousand MT largely due to active intervention by the state government in the promotion of this sector reflected in budgetary increase.
- The State is among the top five major states in the country in terms of growth in the fishing and aquaculture sector.

- Out of the total fish production, freshwater fish constitutes 66%, brackish water 14%, and marine fish 20% for the year 2020-21 (Economic and Statistical Organisation, Government of Odisha 2022).
- Within the fishery sector, the inland fisheries sector has shown spectacular growth, which is one of the best in the food and agriculture sector.

The **demand for fish** is huge since around 94% of the 45 million population in the state consumes fish.

- Odisha has been among the top fish consuming states with per capita annual consumption of 16.34 kg in 2020-21 from 7.71 kg in 2000-01.
- The fish produced in the state is also consumed at a national level as well as exported beyond to multiple countries i.e., in international markets such as the USA, Europe, Japan, China, ASEAN and Middle Eastern countries.
- The total fish exports from Odisha have increased by 18.6% in 2021-22 over 2020-21.
- Out of the 0.25 million tonnes of fish exported to other states and overseas, marine fish and brackish water fish constituted 79% of the total exports.
- Furthermore, seafood exports from the state have tremendously increased by 9 folds in the last two decades and reached INR 3,108 crores with a volume of 61,000 tons during 2020-21.

Odisha is endowed with the rich potential of inland, brackish water, and marine fishery resources. The state has 6.88 lakh ha of freshwater resources, 4.18 lakh ha of brackish water resources, and 480 km of coastline for fisheries development. By judiciously harnessing these resources, fish production from capture, culture, and culture-based capture fisheries could be substantially augmented to cater to the domestic and export market.

Energy mix in fishery sector

- In the case of inland fishing, mostly non-mechanized boats are used.
- In 2020-21, Odisha had around 1,876 motorized mechanical fishing vessels, 12,692 motorized non-mechanical fishing vessels, and 13,640 non-motorized fishing vessels.
- The mechanized fishing vessels for inland and marine fishing in Odisha run on diesel and except for trawlers, most of the boats and their drive train are developed by local mechanics with the limited technical know-how on fuel efficiency.

Energy Consumption of the Sector

The fisheries sector in Odisha, a coastal state in India, plays a vital role in supporting livelihoods and contributing to the state's economy. However, like any other sector, the fisheries sector also requires energy for various activities, and its energy consumption has implications for sustainability and environmental impact.

- The primary source of energy consumption in the fisheries sector is diesel being consumed by fishing vessels and pumps.
- The annual diesel consumption of motorized fishing vessels has increased with a CAGR of 6.8% from 2017-18 to 2020-21.
- In terms of water farms, both the annual diesel and electricity consumption has increased by a CAGR of 4.5% in brackish water and by 3.9% in the freshwater sector from 2017-18 to 2020-21.
- Additionally, the annual electricity consumption in cold storage or processing plants has also increased to 60.7 MUs in the same period.

In the baseline scenario, the total energy demand for the fisheries sector grows at the CAGR rate of 2.58% between 2022 and 2040. In absolute terms, the total energy demand is poised to increase from 1.36 TWh in 2022 to 2.16 TWh in 2040. Major energy consumption in the sector takes place through fishing activities which are mostly driven by mechanized and non-mechanized fishing vessels etc. Oil is the major fuel source for running fish farm equipment. The figure below presents the projected energy demand of the fishery sector by fuel and technology type for different fishing areas:

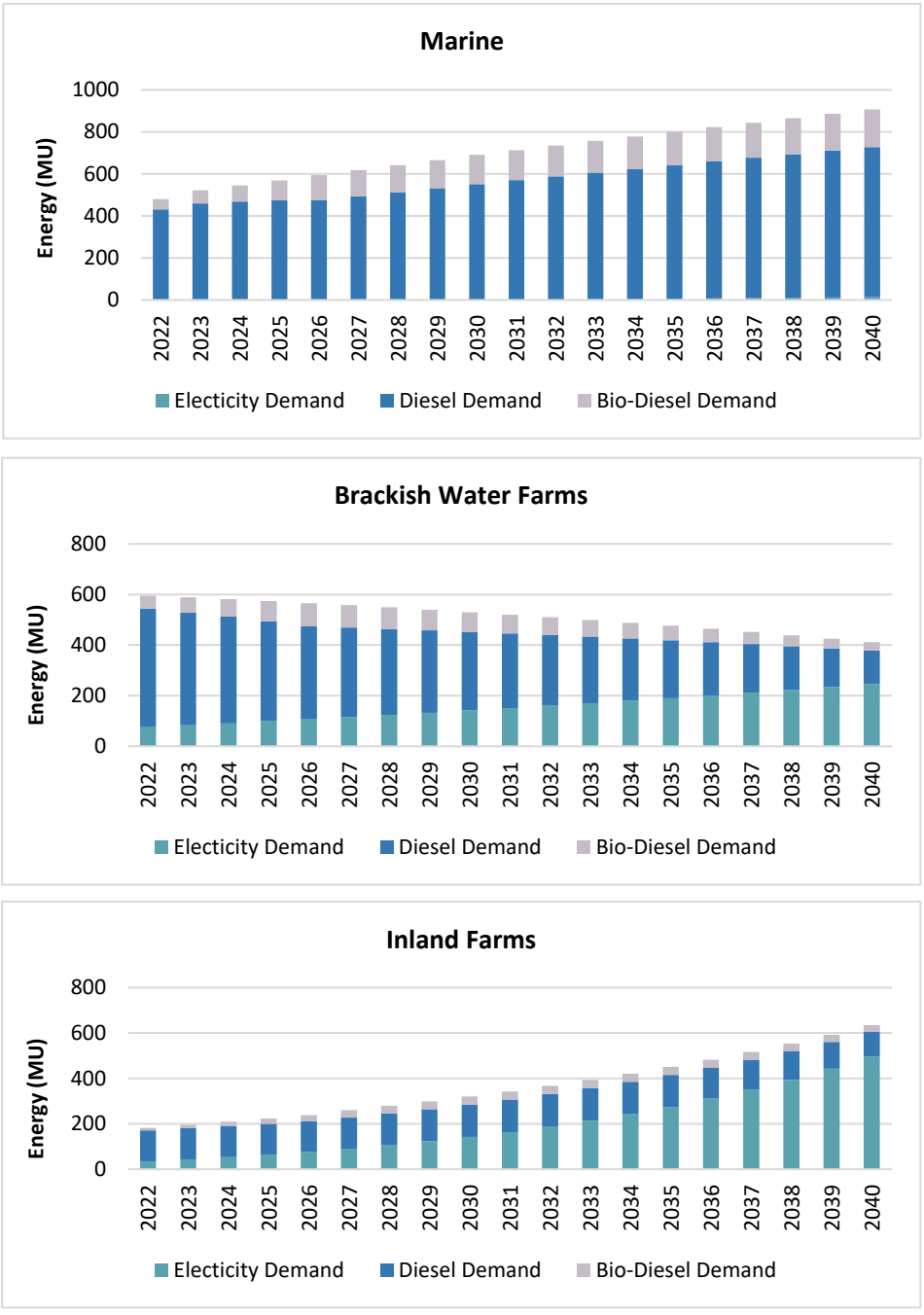


Figure 33: Energy demand for Fisheries sector (Vessels and Pumps) in Odisha

Existing initiatives undertaken in the State

The State Government through a wide range of incentive-based schemes and programmes has attracted a large number of farmers and entrepreneurs into inland and brackish water aquaculture. Implementation of several initiatives like Odisha Fishery Policy 2015, Matsya Pokhari Yojana, adoption of new technology like biofloc, cage culture, and other initiatives in fishery substantially contributed towards an improvement in production, productivity, exports, availability, and per capita consumption of fish.

Centrally Sponsored Schemes:

1. Pradhan Mantri Matsya Sampada Yojana' (PMMSY), 2020

The scheme focuses on the sustainable development of India's fisheries sector and is a part of the Atmanirbhar Bharat scheme. The scheme targets modernizing fishery management and improving the socio-economic welfare of fisheries. With the implementation of the scheme, the government aims to help reduce post-harvest loss from 20–25% to 10%, double the incomes of fishers and fish farmers, and generate an additional 55 lakhs of direct and indirect employment opportunities. To date, total project investment of INR 7243 crores (FY 2020-22) has been done under PMMSY. There are several sub-components under the schemes such as providing support for the construction of new ponds, modernization of existing cold storages, increase in penetration of solar fishing vehicles, group accident insurance, etc. Under this scheme, 11.5 lakh fishermen of Odisha have also been provided insurance coverage during 2021-22. The scheme also involves providing autorickshaws with ice boxes, motorcycles with ice boxes, refrigerated trucks, and insulated vehicles to the fishermen on subsidy.

2. Fisheries and Aquaculture Infrastructure Development Fund (FIDF), 2020

This scheme envisages the creation of fisheries infrastructure facilities both in the marine and inland fisheries sectors and augments the fish production to achieve the target of 15 million tonnes by 2020. There are several investment activities that fall under the roof of the FIDF Scheme. Any project under FIDF is eligible for a loan up to 80% of the estimated/actual project cost. The rest amount is to be contributed by the beneficiary as margin money.

State Sector Schemes:

3. Odisha Fishery Policy, 2015

The latest issued Odisha Fishery Policy offers great opportunities for the development of fresh water, brackish water, and marine fisheries in the state. Under the inland sector, with the technical support of "WorldFish", activities like Carp-Mola poly culture, GIFT tilapia demonstration, and cage culture in reservoirs were undertaken. The policy aims to promote sustainable development of inland, coastal, and marine capture and culture fisheries to attain self-sufficiency in fish production for domestic consumption and the development of the seafood industry. The use of low-cost energy sources in fish processing, particularly non-conventional energy sources shall be considered and promoted as stated in the policy. Furthermore, the policy promotes the use of renewable energy-based pilot cold chain projects, wherever feasible.

4. Promotion of intensive aquaculture (fish farming) through introduction of Bio-floc technology, 2021

The scheme aims at the sustainable intensification of freshwater fish and brackish water shrimp using bio-floc tanks, thus increasing their productivity and subsequent income earned through its sale. The objective of this scheme is to encourage farmers, entrepreneurs, and unemployed youth to delve into fisheries. This promotes high-yielding intensive fish farming in a small area of bio-floc tank size. There is a provision of 40% financial assistance for the general category and 60% for SC/ST/Women beneficiaries. The Government of Odisha over two years has placed more than INR 40 crores towards subsidies for encouraging Bio-floc fishery.

5. Cage culture in reservoirs

The cage culture is an emerging technology for the intensive production of fish and has a huge potential for increasing fish production in the state. Recently, the policy for leasing water areas in reservoirs for undertaking cage Culture fisheries was launched by the state government. The Fisheries Department has already installed 322 rectangular cages in 26 reservoirs and over 49 entrepreneurs have leased out water areas in Hirakud Reservoir for taking up cage culture aqua culture. The PMMSY scheme also has a provision for assistance in taking up cage culture.

6. Popularization of Fisheries Machineries/Equipment, 2020-21

With the goal of maximizing farmer profit by preventing disease outbreaks, stabilizing biotic factors, and achieving a quick turnaround time between two crops as well as increasing fish and prawn production and productivity in a sustainable manner, a 50% subsidy is being offered for the purchase of fisheries equipment or

implements such as aerators, air blowers, bio-security nets and, fishing net. In 2020–21, 1676 beneficiaries received coverage, amounting to a total expenditure of INR 30 lakhs.

7. Mukhya Mantri Krushi Udyog Yojana (MKUY), 2018

This is a flagship scheme launched by the state government which provides subsidies up to INR 50 lakhs to farmers and entrepreneurs for taking up any fishery-related activity in the state including commercial fish/prawn/crab farming, hatchery, processing units, and harvest and post-harvest technologies like vessels, gears, value addition, cage culture aquaculture, feed mills, etc. This makes the loan procedure hassle-free and easier encouraging entrepreneurs in the state. Recently, the state government authorized a five-year budget provision as part of this programme. The budget allocation for this five-year period is for receiving INR 484 crores, which would be given as a subsidy to the beneficiaries.

8. Dedicated Fishery Feeder Programme by Govt. of Odisha, 2014-15 to 2016-17

In order to promote pisciculture, the Government of Odisha decided to provide dedicated electrical feeders to the agriculture and fishery sectors. Additionally, Gram Panchayat tanks are given on long-term lease (3-5 years) to the identified Women Self Help Groups (WSHGs) for pisciculture.

The state government spends around INR 100 crores per annum towards subsidies for farmers to take up new fish tanks for the expansion of intensive inland and brackish water aquaculture. Through a liberal policy, long-term leases of Panchayat tanks are provided to women SHGs, and currently, around 8300 women Self Help Groups are taking up inland aquaculture, under the flagship "Mission Shakthi" programme of the State Government.

Description of Aggressive Scenario for sector (Scenario 3)

The total energy demand for the fishery sector is expected to grow at the CAGR rate of 1.08% between 2022 and 2040. In absolute terms, the total energy demand will increase from 1.36 TWh in 2022 to 1.66 TWh in 2040. Major energy consumption in the sector takes place through fishing activities which are mostly driven by the vessels, pumps, aerators, trawlers, etc. Oil is the major fuel source for running this farm equipment.

The figure below presents the projected energy demand of the fishery sector by fuel and technology type for different fishing areas - (Note: For detailed assumptions please refer to section 4.1 of the report)

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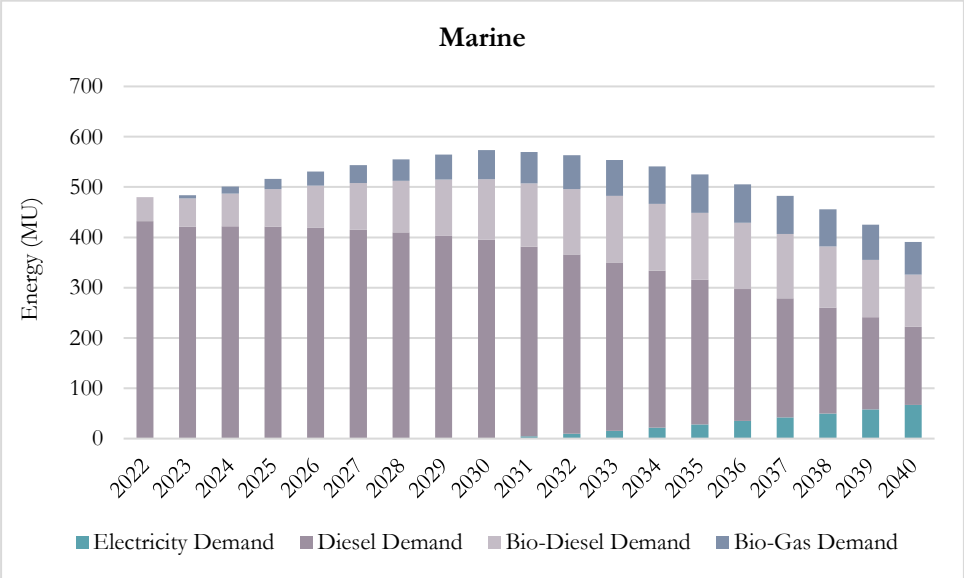
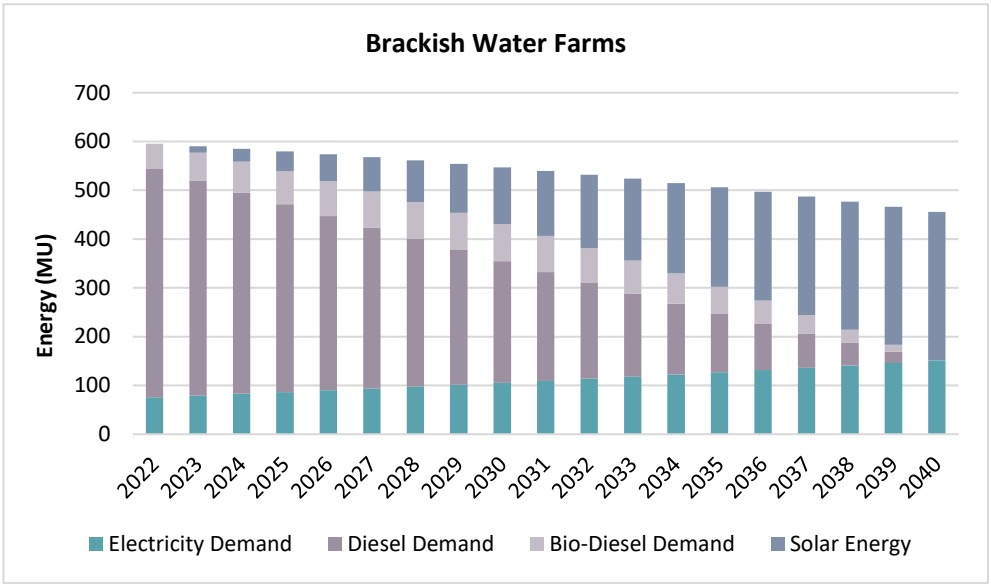




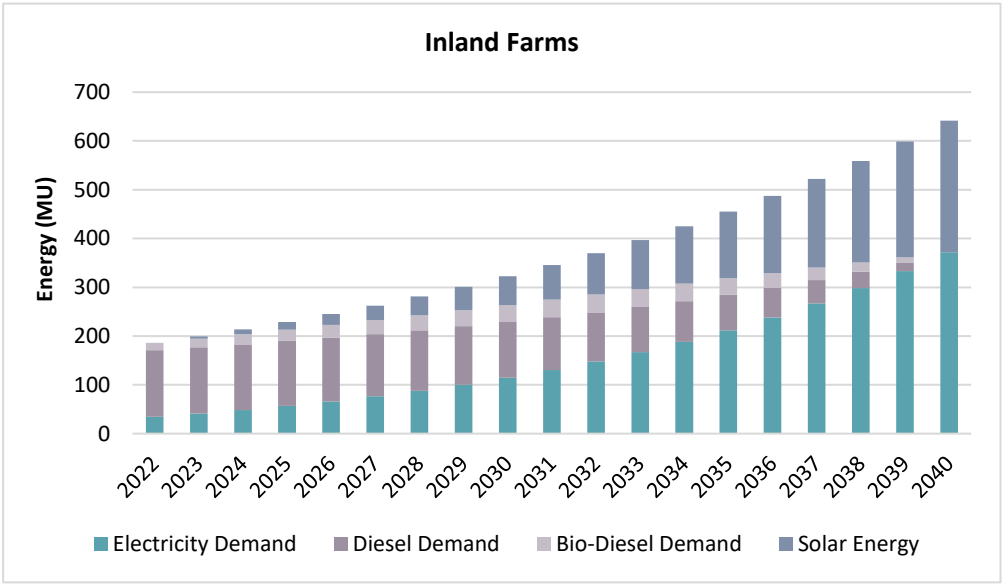


Figure 34: Energy demand for Fisheries (Pumping and Vessels) sector in Odisha

Description of Decarbonization Scenario for sector (Scenario – 4)

The total energy demand for the fishery sector is expected to grow at the CAGR rate of 2.3% between 2022 and 2040. In absolute terms, the total energy demand will increase from 1.36 TWh in 2022 to 2.06 TWh in 2040. Major energy consumption in the sector takes place through fishing activities which are mostly driven by vessels, pumps, aerators, trawlers, etc. Oil is the major fuel source for running this farm equipment.

The figure below presents the projected energy demand of the fishery sector by fuel and technology type for different fishing areas: (Note: For detailed assumptions please refer to section 4.1 of the report)

Figure 35: Energy demand for Fisheries (Pumping and Vessels) sector in Odisha

Sectoral Vision

In the baseline scenario, the fishery sector accounts for ~0.24% of the total energy consumption of the state in 2040. The existing policies and their corresponding targets can help achieve the intended energy goal for the state. The consumption of diesel from trawlers and fishing vessels can be reduced by maximizing the use of renewables

and increasing fuel efficiency leading to reduction of operational costs. The views on vision document have been shared by the Directorate of Fisheries, Cuttack.

Vision:

State shall ensure 100% utilization of the available local resources by 2040 for fulfilling the energy needs of the fishery sector alongside reducing the costs involved in fuel consumption of fishing vehicles and for fish farming activities. State shall promote and ensure penetration of solar power and energy efficiency in fish harvesting processes by ensuring a shift of fuel for fishing vessels from diesel to solar and electricity.

Action Plan

a) **Objective:** State shall increase penetration of solar power in fish harvesting processes

Activity:

A.1: State shall ensure a shift of fuel for fishing vessels from diesel to solar

A.2: State shall ensure a shift of fuel for pumps used in water farm from diesel to solar and electric

A.3: State shall ensure an increase in penetration of solar based biofloc tanks

b) **Objective:** State shall increase penetration of renewables and energy efficiency in fishing activities

Activity:

A.1: State shall promote the shift of fuel for fishing vessels from diesel to CBG and biodiesel

A.2: State shall ensure fuel efficiency of marine and inland fishing vessel.

Table 28: Summary of action plans for fishery sector

SL No.	Recommendation Category	Recommendation	Types of scenarios	Time Period	Type of intervention	Implementing Agency
1	Increase penetration of solar power and energy efficiency in value chain	Develop and implement financial mechanisms to increase uptake of solar power options in fishing vessels	Aggressive; Decarbonization	Short to Medium	Financial	Fisheries Dept., GRIDCO, OREDA
2		Undertake awareness programs to disseminate benefits of switching to solar power for fishing vessels	Aggressive; Decarbonization	Short to Medium	Awareness generation	Fisheries Dept., OREDA
3		Develop and implement mechanisms to increase uptake of solar power options in pumps and biofloc tanks	Aggressive; Decarbonization	Short to Medium	Financial, Technical, Institutional	Fisheries Dept., GRIDCO
4		Promotion of the use of CBG as an alternate fuel source for the fishing vessels	Aggressive; Decarbonization	Short to Medium	Financial and Market Development	Fisheries Dept., OREDA
3	Increase energy efficiency in value chain	Undertake stakeholder outreach programs to create awareness on the methods of increasing fuel efficiency of marine fishing vessels	Aggressive; Decarbonization	Short to Medium	Awareness generation	Fisheries Dept., OREDA
4						

Recommendations for Fisheries Sector

Provided below are details of the action plans defined for the state in the above table:

1. **Develop and implement financial mechanisms to increase the uptake of solar powered electric fishing vessels**

The average power requirement of marine fishing vessels is about 100-160 HP (IOP Conference Series 2021), requiring solar panels which will take considerable area as well as increase the overall weight of the vessel. Alternately, solar power can be used to supply auxiliary power i.e., the power required for various purposes e.g., cooking, charging mobile, signal light, selecting fish, etc. In most cases, the electric power is supplied by a battery that is charged through a dynamo synchronized with a trawler engine. These dynamos require diesel to serve electric power. Solar power can be used instead of using diesel to charge the batteries.

In contrast to marine fishing vessels, inland fishing vessels have a lower power requirement of around 5-10 HP (EPROPULSION 2022) Unlike a marine fishing boat where retrofitting of existing fishing vessels is undertaken, new vessels fitted with solar panels can be introduced in case of the inland fishing vessel. An interest-free loan can be provided to beneficiaries to stimulate the adoption of solar options for fishing vessels.

Pilot projects can be undertaken to introduce solar power in marine fishing vessels. In this case, OREDA can provide technical assistance, while financing can be provided by the Department of Fisheries. The scheme, promoted through the arms of the Fisheries department directly involved with individual fishermen and marine fishing organizations/associations, should solicit voluntary participation. An initial assessment can be carried out by OREDA, providing the technical requirements and liaising with an independent agency to provide the quotation to the beneficiary. In case concurrence is received from the beneficiary, OREDA can provide support to the beneficiary in securing the finances required for undertaking the project. Some case studies of solar powered electric boats are depicted below:

- **NavAlt Solar & Electric Boats:** NavAlt is a company based in Kochi, Kerala, that specializes in manufacturing solar-powered electric boats. They have developed solar-electric fishing vessels that are equipped with solar panels to charge the onboard batteries.
- **Dabbaguli Solar Fishing Cooperative Society:** This cooperative society, based in Karnataka, has implemented a solar-powered fishing fleet. They have installed solar panels on their boats to generate electricity and charge batteries, reducing the dependence on diesel for their fishing operations.
- **Navgathi Marine Design & Constructions Pvt. Ltd:** Navgathi, located in Kochi, is known for designing and building solar-powered fishing boats. Their vessels are equipped with solar panels that charge the

The financial assistance proposed can be divided into two components as given below:

a) Loans: 90% of the total installation cost can be provided to the beneficiary as interest free loan. The preferred organization for disbursal and monitoring of the loan should be through a co-operative like BENFISH, which has a greater scope of interface with individual fishermen than commercial banks.

b) Beneficiary capital: 10% of the capital will be paid by beneficiary as a one-time payment. An alternate arrangement of part payments can be provided to the beneficiary provided financial credibility of the beneficiary has been established.

Based on the assessment in Odisha Energy Model the following figures have been obtained:

Decarbonisation scenario:

Table 29: Investment requirement to increase penetration of solar power in marine fishing

Term	Number of vessels	Target Penetration	Numbers	Net Cost (INR Crore)	Diesel savings (L/yr)	Energy savings (MU/yr)	Cost savings (INR Crore/yr)	Payback period (in year)
Short	15,969	5%	798	3.5	282,054	18	2.7	1.3
Medium	20,969	10%	2,097	9.2	740,734	47	7.1	1.3
Long	30,969	30%	9,291	40.9	3,281,956	208	31.6	1.3

Assumptions:

i. Cost of solar panel is INR 44/W (Loom Solar 2023)
ii. Total solar power requirement for an average marine vessel is taken 1000 W (E3S Web of Conferences n.d.)
iii. Electricity generated by 2*500W solar modules is 4 KWh in 1 day (Scientific Research 2018)
iv. Entire electricity generated is consumed and no battery is installed
v. Fuel savings is calculated by considering 240 days of fishing per year
vi. Power generated by 1L diesel is 10.6 kWh
vii. Total number of marine fishing boats in each term taken from Odisha Energy Model (Odisha Energy Model Analysis, 2022)
x. Cost of diesel is INR 96.28 /litre
viii. GCV of diesel 11840 kcal/kg
ix. Density of diesel 0.8263 kg/litre

2. Develop and implement financial mechanisms to increase uptake of efficient electric power options in fishing vessels

Odisha has a significant fishing industry that relies heavily on power sources for fishing vessels. Developing and implementing financial mechanisms to increase the uptake of efficient electric power options in fishing vessels can contribute to sustainable fishing practices and reduce environmental impacts. Here are some steps that Odisha can take:

a) **Financial Incentives:** Odisha can offer financial incentives to fishing vessel owners to encourage them to adopt efficient electric power options. This could include subsidies, grants, or low-interest loans for the purchase of electric propulsion systems, electric generators, or other electric power equipment for fishing vessels. These incentives can help offset the initial costs of transitioning to electric power and make it more affordable for fishing vessel owners.
b) **Tax Benefits:** Odisha can provide tax benefits, such as reduced or waived taxes, for fishing vessel owners who choose to install and use efficient electric power options. This can provide a financial incentive for vessel owners to invest in electric power options and promote their adoption.
c) **Partnerships with Financial Institutions:** Odisha can collaborate with financial institutions, such as banks and credit unions, to develop special financing programs for fishing vessel owners who wish to switch to efficient electric power options. These programs can offer favorable loan terms, such as low interest rates or longer repayment periods, to make the transition more financially viable for fishing vessel owners.

By implementing these financial mechanisms, Odisha can encourage the uptake of efficient electric power options in fishing vessels, which can contribute to sustainable fishing practices, reduce greenhouse gas emissions, and protect the marine environment. It is important to involve local fishing communities, stakeholders, and experts in the development and implementation of these financial mechanisms to ensure their effectiveness and relevance to the local context.

3. Undertake awareness programs to disseminate benefits of switching to solar power for fishing vessels

The use of solar power for inland and marine vessels provides substantial cost savings for the user. The benefit of these alternatives can be disseminated by the respective beneficiaries (viz. trawler owners, 'bheri' owners, individual fishermen) through co-operatives like BENFISH. This ensures substantial outreach is achieved

4. Develop and implement mechanisms to increase uptake of solar power options in pumps and biofloc tanks

Odisha can implement several mechanisms to increase the uptake of solar power options in fish farming pumps and biofloc tanks. The following measures can be adopted:

a) **Awareness Campaigns:** Conducting awareness campaigns among fish farmers and stakeholders to educate them about the benefits of solar power pumps for fish farming. This can include disseminating information through workshops, seminars, and training programs, as well as using local media channels to raise awareness about the advantages of using solar power pumps in fish farming.
b) **Subsidies and Incentives:** Providing subsidies or financial incentives to fish farmers for the installation of solar-powered pumps and biofloc tanks. This can help reduce the initial investment cost and make solar power options more attractive and accessible to fish farmers.
c) **Technical Assistance:** Offering technical assistance to fish farmers to help them understand the technical aspects of solar power systems, including installation, operation, and maintenance. This can include providing training and guidance on the selection of appropriate solar power systems for different fish farming setups, as well as offering ongoing technical support.
d) **Financing Options:** Collaborating with financial institutions to offer favorable financing options, such as low-interest loans or lease-to-own arrangements, for fish farmers to invest in solar power systems. This can help overcome financial barriers and make solar power options more affordable for fish farmers.
e) **Demonstration Projects:** Setting up demonstration projects in collaboration with fish farmers to showcase the successful implementation of solar power systems in fish farming pumps and biofloc tanks. This can help build confidence and trust among fish farmers by providing them with tangible examples of the benefits of using solar power.

Additionally, developing and implementing supportive policies and developing joint initiatives, pilot projects, and knowledge sharing can accelerate the adoption of solar power in fish farming practices.

By implementing these mechanisms, Odisha can promote the uptake of solar power options in fish farming pumps and biofloc tanks, leading to sustainable and environmentally-friendly fish farming practices, reduced reliance on fossil fuels, and improved livelihood opportunities for fish farmers.

Aggressive scenario:

Table 30: Investment requirement to uptake use of solar pumps in fish farming (inland and brackish)

Term	Total no. of pumps (Diesel)	Target Penetration	Solar pumps (nos.)	Cost of solar pumps (INR Cr)	Annual interest (INR Cr)	Annual diesel savings (INR Cr)	Actual Cost savings (INR Cr)	Payback period (in years)
Short	131,119	10%	9,362	215	4.3	36	21	10.27
Medium	194,790	25%	32,504	747	15.0	129	77	9.75
Long	387,824	60%	126,315	2905	58.1	661	458	6.34

Assumptions:

i. Total no. of pumps including diesel and electric added in each term is taken from Odisha Energy Model (Odisha Energy Model Analysis, 2022)
ii. Solar pumps are considered to replace only the diesel pumps out of the total number of pumps
iii. Cost of 5 HP subsidised solar pump is INR 2,30,000 (Kenbrook Solar 2023)
iv. Annual usage of diesel pumps for inland fish farming is 253 litres/pump (Fisheries Department)
v. Annual usage of diesel pumps for brackish fish farming is 872 litres/pump (Fisheries Department)
vi. Operating cost of solar pump is 5% of capital cost (Niti Aayog 2017)

vii. Cost of diesel is INR 96.28 /litre
viii. Interest rate for loan is 2% (Bank of Baroda n.d.)

5. Promoting the use of CBG as a fuel source for the fishing vessels

The use of CBG as a fuel for fishing vessels in Odisha could have a number of benefits, including reducing emissions, promoting sustainable energy production, and supporting the local economy through the development of biogas plants. However, careful planning and coordination will be necessary to ensure that sufficient infrastructure is in place and that the use of CBG is economically viable for the fishing industry.

In order to promote the use of CBG, the government can provide subsidies and incentives to lower the cost of CBG production and also develop fishing vessels equipped with engines that are capable of running on CBG. Recently, up to 580 boats were converted by the government to run on compressed natural gas (CNG) instead of diesel in the Ganga River in Varanasi. These were made possible by Gail's installation of city gas infrastructure. Oil minister Hardeep Puri, without providing a timeframe, even

6. Undertake stakeholder outreach programs to create awareness on the methods of increasing fuel efficiency of marine fishing vessels

Undertaking stakeholder outreach programs can be an effective way for Odisha to create awareness about methods to increase fuel efficiency of marine fishing vessels. Here are some steps that can be taken:

a) **Develop Outreach Strategy:** Develop a comprehensive outreach strategy that outlines the objectives, target audience, key messages, and communication channels for the awareness campaign. Consider the cultural, linguistic, and socio-economic diversity of the stakeholders in Odisha including fishing vessel owners, operators, fishermen, fishing associations to tailor the outreach strategy accordingly.
b) **Conduct Awareness Programs:** Organize awareness programs such as workshops, seminars, and training sessions in fishing communities, fish landing centers, and other relevant locations to disseminate information about methods to increase fuel efficiency of marine fishing vessels.
c) **Provide Technical Information:** Provide technical information about best practices, technologies, and methods to increase fuel efficiency of marine fishing vessels, such as proper vessel maintenance, optimizing gear and engine settings, reducing drag, and adopting fuel-efficient fishing techniques. Offer practical guidance and training on how to implement these methods in real-world fishing operations.
d) **Demonstrate Success Stories:** Share success stories and case studies of fishermen or fishing vessel owners who have adopted fuel-efficient practices and have benefited from increased fuel efficiency. These success stories can serve as role models and inspire others to follow suit.
e) **Engage Local Leaders:** Engage local leaders, such as community leaders, fishery cooperatives, and influential individuals, to support and promote the awareness campaign. Local leaders can play a key role in influencing the attitudes and behaviours of their communities towards adopting fuel-efficient practices.
f) **Utilize Media Channels:** Utilize various media channels, including print, electronic, and social media, to disseminate information about fuel-efficient practices for marine fishing vessels. Develop engaging and informative content, such as articles, videos, infographics, and social media posts, to reach a wider audience and raise awareness about the importance of fuel efficiency in the marine fishing industry.
g) **Provide Incentives:** Offer incentives, such as subsidies, tax benefits, or rewards, to encourage fishermen and fishing vessel owners to adopt fuel-efficient practices. This can provide a tangible incentive for stakeholders to take action and adopt fuel-efficient methods in their fishing operations.
h) **Foster Partnerships:** Foster partnerships with relevant stakeholders, including government agencies, NGOs, research institutions, and private sector entities, to collectively work towards increasing fuel efficiency in the marine fishing industry. Collaborate on joint initiatives, research projects, and capacity-building programs to promote awareness and adoption of fuel-efficient practices.

i) **Monitor and Evaluate:** Monitor and evaluate the effectiveness of the outreach programs through regular assessments and feedback from stakeholders. Modify the outreach strategy as needed based on feedback and lessons learned to ensure continuous improvement and effectiveness of the awareness campaign.

By undertaking stakeholder outreach programs, Odisha can create awareness about methods to increase fuel efficiency of marine fishing vessels, which can lead to reduced fuel consumption, cost savings, and environmental sustainability in the marine fishing industry

7. Undertake mechanisms to increasing fuel efficiency of trawlers

Trawling is one of the most energy intensive fishing activity. It consumes nearly 5 times more fuel compared to passive fishing methods such as longlining and gillnetting and over 11 times more fuel compared to purse seining for every kilogram of fish produced. Percentage of fuel cost in the operational expenditure of trawlers may vary between 45 and 75%, depending on installed engine power and duration of voyage. Hence the largest potential for fuel conservation exist in trawling. There are multiple interventions that can be undertaken, without requirement of additional cost, to improve the efficiency of trawlers as given below:

Introduction of the following measures can be undertaken:

a) Economic vessel speed (Boopendranath n.d.): Vessel speed is the single most important factor affecting fuel consumption of the vessel. The fuel consumption drastically increases as the vessel approaches maximum speeds, due to great increase in wave breaking resistance. It has been shown 35 to 61% savings in fuel is possible for a reduction of 10-20% speed.
b) Operating RPM range of engines (Boopendranath n.d.): Modern marine diesel engines will run most economically at a service speed of 80% of the maximum continuous rating of the engine. The propeller design and size should be so selected as to allow the engine to operate in the area of lowest specific fuel consumption. A 3% reduction in engine RPM is reported to reduce fuel consumption by 10% and 11% reduction in RPM reduce fuel consumption by 30%.
c) Hull design, displacement & maintenance (Boopendranath n.d.): Reduction in power requirements can be achieved by (i) increasing length of water line (LWL) and (ii) reducing displacement wherever possible at the design stage, and (iii) by taking measures for control of hull fouling. Though fuel consumption can reduce by 20-25% there is a capital cost involved in implementing these solutions.

Improving fuel efficiency in trawlers holds immense potential for the fishery department in Odisha. By implementing the above measures to enhance fuel efficiency, such as optimizing engine performance, reducing drag, and adopting more efficient vessel designs, the state can achieve multiple benefits. Firstly, it would directly address the issue of rising fuel costs, which is a significant concern for fishermen. Secondly, improved fuel efficiency would have a positive environmental impact, reducing carbon emissions and minimizing the ecological footprint of the fishing industry. Additionally, the Odisha government can initiate pilot projects to validate the results obtained from existing literature on fuel efficiency interventions. If these pilots demonstrate positive outcomes, such measures can be scaled up to increase fuel efficiency across the state's fishing fleet. This would not only lead to economic savings but also contribute to sustainable fishing practices, ensuring the long-term viability of the sector while preserving marine resources.

The monetary benefits from the initiatives given above can be disseminated to the trawler operators and owners through awareness programmes. Agencies under the Fisheries Department which are associated with trawler owner/operator associations/individuals can undertake workshops/seminars/meetings to disseminate the benefits.

Investment Required

The following table provides the investment required in terms of unit cost of preferred equipment such as solar pumps and fishing vessels and the number of units requiring such equipment in 2040:

Table 31: Investment requirement fisheries sector in decarbonization scenario

SL. No.	Particulars	Average cost per unit (INR)	No. of units by 2040	Total Cost in INR Crores
1.	Solar Pumps (inland and brackish farms)	2,29,981	126,315	2905
2.	Solar powered electric fishing vessels[10]	44,021	9291	40.9

6.3. Industry Sector

Overview of Sector

Odisha is among the most industrialised states in the country and large portion of the state's working population is engaged in industrial activities. In FY 2022-23, the industry sector contributed 41.3% to the State's Gross value added (GVA) compared to 28.5% at the National level. Over the years, the State government has taken multiple initiatives like Make in Odisha and reforms under "Ease of Doing Business" to accomplish steady and fast industrialization. Stable governance, government's liberalized policies, single-window facilitation and empowering of state institutions have resulted in rapid industrialization in the state through massive investment inflow.

High share of thermal captive power plants: Odisha's industrial profile is dominated by energy intensive sectors such as steel, aluminum, cement etc. Odisha is India's largest producer of steel and stainless steel.

Most of these plants rely on captive thermal power plants to meet their electricity needs. Since these processes require reliable, 24x7 power, they have traditionally preferred captive plants. Odisha has ~12 GW of thermal captive capacity, the highest in the country. The chart below shows the details of captive capacity:

Captive Installed Capacity	
ALL-INDIA	76.2 GW
TOP 5 STATES	
1. Odisha	11.6 GW (15%)
2. Gujarat	8.9 GW (12%)
3. Madhya Pradesh	8.3 GW (11%)
4. Tamil Nadu	7.7 GW (10%)
5. Chhattisgarh	6.6 GW (9%)

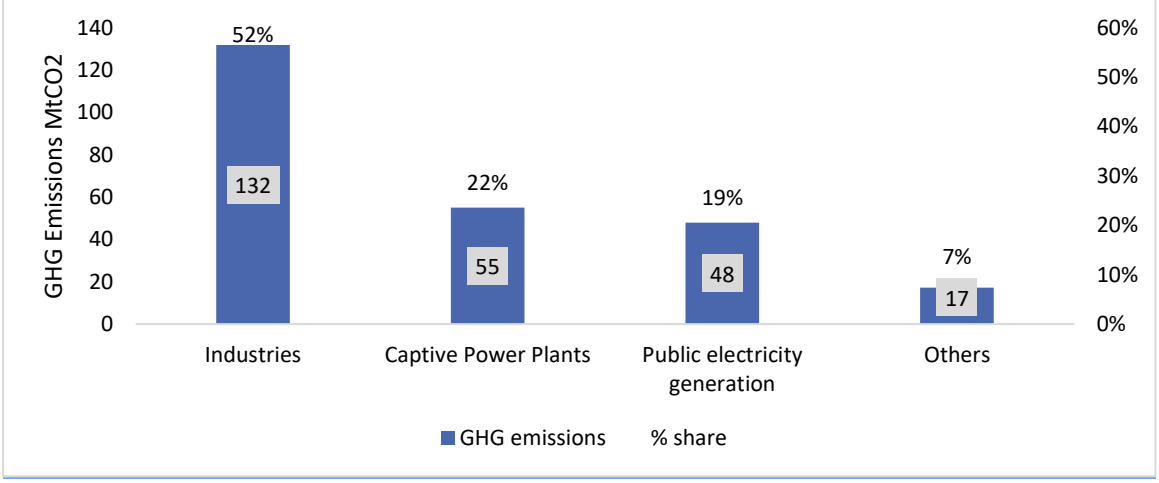
	Odisha	Gujarat	MP	TN	Cgarh
Coal	92%	47%	86%	47%	95%
Diesel	5%	12%	9%	27%	2%
Gas	3%	33%	2%	4%	1%
Solar	0.5%	2%	0.1%	3%	0.5%
Wind	0%	7%	3%	19%	0%

Sector wise break up for Odisha	
Aluminum	50.86%
Iron & Steel	38.48%
Mineral Oil & Petroleum	3.30%
Non-Ferrous	2.27%
Fertilizer	1.50%
Cement	0.95%
Paper	0.81%
Food Products	0.37%
Mining & Quarrying	0.26%
Rubber	0.14%
Sugar	0.12%
Light Engineering	0.03%
Collieries	0.02%
Jute	0.01%
Chemical	0.01%

Hard-to-abate energy intensive industries: These energy intensive industries rely on fossil fuels for meeting process heating requirements and also for process feedstock. For example, coke is an integral part of steel manufacturing wherein it is used as a reducing agent for iron oxide. As a consequence, emissions from fossil fuel

[10] This includes fishing vessels wherein solar panel is used only to charge the batteries and not power the entire vehicle unlike in case of EVs

combustion in industries and from their captive power plants are the largest contributors to GHG emissions in the State as shown in the chart below (GHG Platform India 2022)



Note : Data as of 2018

Energy Consumption of Sector

The energy consumption of the sector in business-as-usual scenario is projected to increase at a CAGR of 7.9% as shown in the table below :

Sector	2022	2025	2030	2035	2040	CAGR (%)
Industrial	172.0	214.5	311.9	456.3	671.0	7.9%

(Values in TWh)

Existing initiatives undertaken in the state

1. **Industrial Policy Resolution 2022**

   Multiple initiatives have been taken to promote decarbonisation under the Industrial Policy Resolution, 2022. Some of the key initiatives are as follows:

   A. Green Hydrogen and Green Ammonia have been identified as 'Thrust Sector' and special incentives are provided under the IPR such as:
      i. 30% capital investment subsidy on actual investment in plant & machinery (excluding the cost of land and building) with no upper cap
      ii. 100% exemption/reimbursement of cross subsidy surcharge & additional surcharges and state transmission charges on renewable energy procured from state-based renewable energy plants/GRIDCO for a period of 20 years
      iii. 100% exemption from payment of Electricity Duty for a period of 20 years from the date of commencement of commercial production
      iv. 100% exemption stamp duty

   B. Special Incentives have been provided to existing and new industrial units for setting up Captive Renewable Energy Plants within the state with rooftop solar, floating solar, wind, hydro, pumped storage hydro, battery energy storage and hybrid of these technologies. The following incentives shall be provided to such captive RE plants:
      i. 30% capital investment subsidy for plant and machinery
      ii. 100% exemption of Electricity Duty for 20 years
      iii. 100% exemption / reimbursement of state transmission charges for 20 years
      iv. Provision of long-term lease of water reservoir surface area for floating solar power plant at a total premium of Rs.1 lakh/acre

2. **Green tariff by DISCOMs**

Industries can procure power from Discoms under "Green Tariff" category and get a Green Consumer Certification by DISCOMs. Consumers have to pay the tariff applicable to that category plus Rs. 0.25 per unit for green power. This provides one more option to industries to avail clean electricity for their operations.

Description of aggressive scenario

The table below presents the demand summary of the Industrial sector under the Aggressive scenario. The total energy demand for the Industrial sector under this scenario is 151.7 TWh in 2022, 297.4 TWh in 2030, and 625.3 TWh in 2040, thereby, growing at a CAGR of 8.2%. It is observed that the major growing industries are Steel at a CAGR of 9.4%, Cement at a CAGR of 9.0%, and Paper with a CAGR of 8.8% by 2040. The next industries are Aluminium at a CAGR of 7.3% and Fertilizer at a CAGR of 2.3% by 2040 under the Aggressive scenario.

Industrial - Demand Summary under the Aggressive Scenario (in TWh)

Segment	2022	2025	2030	2035	2040	CAGR (%)
Steel	60.1	86.1	131.2	200.0	304.8	9.4%
Aluminium	77.4	102.4	142.4	198.0	275.3	7.3%
Cement	5.3	7.2	11.0	16.7	25.4	9.0%
Fertilizer	6.7	7.5	8.2	9.1	10.0	2.3%
Paper	2.2	3.1	4.5	6.9	9.9	8.8%
Total	151.7	206.3	297.4	430.6	625.3	8.2%

Description of decarbonisation scenario

The table below presents the demand summary of the Industrial sector under the Decarbonization scenario. The total energy demand for the Industrial sector under this scenario is 151.1 TWh in 2022, 294.7 TWh in 2030, and 613.4 TWh in 2040, thereby, growing at a CAGR of 8.1%. It is observed that the major growing industries are Steel at a CAGR of 9.3%, Cement at a CAGR of 9.0%, and Paper with a CAGR of 8.7% by 2040. The next industries are Aluminium at a CAGR of 7.2% and Fertilizer at a CAGR of 2.2% by 2040 under the Decarbonization scenario.

Industrial - Demand Summary under the Decarbonisation Scenario (in TWh)

Segment	2022	2025	2030	2035	2040	CAGR (%)
Steel	59.9	85.8	130.1	197.2	299.0	9.3%
Aluminium	77.2	102.0	141.1	195.2	270.0	7.2%
Cement	5.3	7.2	10.9	16.5	24.9	9.0%
Fertilizer	6.6	7.4	8.2	8.9	9.8	2.2%
Paper	2.1	3.1	4.5	6.8	9.7	8.7%
Total	151.1	205.5	294.7	424.6	613.4	8.1%

Sectoral vision

Vision Statement: State shall ensure environment friendly development of industrial sector by supporting industries in adoption of renewable energy, clean fuels for process requirements and energy efficient technologies.

Note: Industries Department and Steel & Mines Department have provided their views on the vision which have been duly covered in this report.

Action Plan

All industries

Objective : State shall encourage industries to shift to cleaner fuels through regulatory and policy measures, fiscal incentives.

- Prioritising sectors for transitioning to clean fuels

- Focus on clean fuels such as green hydrogen, CBG through R&D and suitable incentives for commercialization
- Support private sector through policy incentives and infrastructure support
- Develop market mechanisms to promote procurement of green products

Views of Industries Department on Vision and Objectives

1. **Prioritising sectors for transitioning to cleaner fuels :**
   a. Ancillary & Downstream - Metal forging units may be encouraged to use green fuels for charging their foundries
   b. Metals - manufacturing of green steel or fossil fuel free steel using Green Hydrogen technology, using renewable energy sources for metal production
   c. Chemicals and Petrochemicals - encouraged to shift to green energy, green ammonia and green hydrogen
   d. Agro & Food Processing - shift/convert boilers to use green fuels like agro-forestry based bio-fuels briquettes, CNG etc.
   e. Data centers - Data centers are energy guzzlers. usage of green energy may be encouraged for promotion of this sector.

2. **Support to private sector:**
   a. Providing special incentives for adopting clean energy measures
   b. Attracting clean energy power and equipment manufacturers to the state
   c. Govt. funded infra projects may be mandated to use "Green Steel,'
   d. Long term ore linkages to have a binding clause to adopt green power.

3. **New policies to be introduced :**
   a. Green Hydrogen & Green Ammonia Policy
   b. Roof Top solar with net metering facility may be encouraged for all large commercial buildings
   c. PNG to be mandated for all industries

4. **Market mechanisms to promote procurement of green industrial products:**
   a. New steel plants to be encouraged to make provisions to utilize x% of energy consumption using green hydrogen as fuel.
   b. Govt. funded infra projects may be mandated to use “Green Steel”
   c. Promote public procurement: preferential purchase of end products by the Government for its internal consumption
   d. Provide viability gap funding if possible

5. **Incentives to encourage investments in renewable energy and green hydrogen:**
   a. 100% exemption on ED, cross subsidy surcharge, additional surcharge, transmission and wheeling charges for 30 years on renewable power banked and utilized for production of green hydrogen and green ammonia
   b. Open Access for sourcing green energy from remote sources to be encouraged as per open access policy.
   c. Floating solar plants to be encouraged basis Odisha's huge hydro projects and water reservoirs.

Steel & Mining

Objective 1 : State shall support in maximizing the penetration of renewable energy in steel production and mining operations

- State shall support industries having coal based captive power plants to shift to renewable power to meet the RPO trajectory
- State shall support development of electricity transmission and distribution infrastructure for reliable power supply to industries
- State shall enable use of abandoned mines for development of renewable energy projects such as solar projects
- State shall enable minimizing use of diesel in mining operations through reliable power supply and switching to electric equipment including electric vehicles

Views of Steel & Mines Department on Vision and Objectives

1. In case of abandoned mines, reclamation measures will be taken up as per the mining closure plan and efforts would be taken up for inclusion of solar projects in abandoned mines as per technical feasibility
2. State shall consider minimizing the use of diesel in mining operations through reliable power supply and switching to electric equipment including electric vehicle
3. Through suitable policy measures Government will encourage deployment of technologies such as Waste Heat Recovery Systems, Carbon Capture and Storage
4. Government will encourage setting up Hydrogen Pilot Plants and will ensure use of

Objective 2 : State shall support deployment of technologies for energy efficiency and carbon emission reduction in steel production and mining operations

- State shall enable deployment of technologies such as waste heat recovery systems through suitable policy measures
- State shall support deployment of carbon capture and storage technologies through suitable policy measures

Objective 3 : State shall enable development of green hydrogen infrastructure for decarbonization of processes in steel production

- State shall enable setting up of green hydrogen pilot plants in the State
- By 2030, State shall ensure usage of natural gas blended with 2% green hydrogen for natural gas based DRI industries in the State[11]

Description of sub-activities

There are primarily three focus areas for decarbonization of industries :

1. Replace fossil fuel based electricity with renewable electricity
2. Adopt clean fuels for process heating requirements
3. Adopt clean fuels for process feedstock requirements

Industrial segment being dominated mainly by the private sector, the role of Government is to design suitable policy and regulatory frameworks and provide supporting infrastructure to encourage adoption of clean fuels. Through policy and regulatory measures, the State can nudge industries to transition to clean energy in such a manner that industries do not lose competitiveness.

The following are the key activities to be undertaken to achieve decarbonization of industries :

Policy and regulatory measures

Renewable Purchase Obligation

Decarbonization of electricity requirement is possible by increasing the share of renewable energy in the electricity supply. Various options such as standalone solar, standalone wind, solar-wind hybrid, solar-wind plus storage etc. are available. With cost reduction and policy incentives, renewable power has become competitive with conventional power.

[11] This is the target specified by the Ministry of Steel, Government of India

The industries with captive thermal power plants have to meet the RPO obligation. As of end of FY 21, Odisha had ~11.88 GW of captive plants of which ~11.81 GW was fossil fuel based capacity.

Issues with RPO for captives in Odisha

As per OERC (Procurement of Energy from Renewable Sources and its Compliance) Regulations, 2021, RPO of only 3% is applicable to captive plants commissioned prior to 01.04.2016. Around 5800 MW (i.e. 49% of total captive capacity in the State) of captive plants were commissioned prior to 01.04.2016. A much lower RPO applies to these plants. This impacts the decarbonization of industries negatively.

In contrast to this, the Electricity (Promoting Renewable Energy Through Green Energy Open Access) Rules, 2022 notified by MoP states that a uniform RPO shall apply to all the obligated entities.

Ministry of Power has notified the RPO trajectory for period FY 2023-24 to 2029-30. The RPO target reaches 43.33% in FY 2030 as per the notified trajectory. As per existing OERC regulations, captives are subjected to a lower RPO than that applicable to utilities. Whereas, captives are the largest electricity consumers – of the total electricity consumption in the State, nearly 2/3rd is through captives. Thus, focus needs to be on decarbonizing captive power generation. (Please see box above for details)

It is important to provide regulatory push for adoption of clean energy. The State Government may take up the matter with OERC for revising the regulations inline with the new MoP RPO trajectory and also to align the State's open access regulations with the Green Open Access Rules notified by MoP. Uniform applicability of RPO can go a long way in decarbonizing the electricity requirements of industries.

New policies

Green Hydrogen is covered as a Thrust Sector under the Industrial Policy Resolution of the State. The State can develop dedicated policy focused on Green Hydrogen. States such as Rajasthan and Uttar Pradesh have issued their draft policies. A comparison of provisions of UP, Rajasthan and Odisha policies is given below :

Sl.	Incentive	Uttar Pradesh – Draft GHP-22	Rajasthan – Draft GHP-22	Odisha: IPR-22 & RE Policy-22
1	**Land**	• 100% exemption - land tax • 100 % exemption - land use conversion charges • 100% exemption - stamp duty	• 100% exemption of Land Tax for 7 years • 100% exemption of Market Fee for 7 years • 100% exemption of Stamp Duty • 100% exemption of land conversion charges	• At a concessional industrial rate, 100% stamp duty exemption, No land conversion charge
2	**Water**	• 50 % exemption - industrial water consumption charges	-	-
3	**Capital/ Interest subsidy**	-	• 5% Interest Subsidy on term loan for investing in plant & machinery, for 5 years upto maximum of INR 10 Crores per year to first 5 units/companies OR • Capital Subsidy equivalent to 20% of the investment made on the plant & machinery, upto maximum of INR 50 Crores	• 30% capital investment subsidy on actual investment in plant & machinery (excluding the cost of land and building) with no upper cap, disbursed in phases over a period of 5 years

4	**Tax**	• 100 % reimbursement of SGST	• Investment Subsidy of 75% of State tax for 7 years	• Reimbursement of 100% of net SGST paid, limited to 200% of cost of plant and machinery
5	**Reimbursement of power tariff**	-	-	• Rs. 3 / unit consumed from local DISCOMs/ GRIDCO for 20 yrs
6	**Exemptions on RE for Green Hydrogen/ Green Ammonia production**	50 % exemption – wheeling charges 50 % exemption – STU charges • 100 % exemption – CSS	• 100% exemption on open access charges, wheeling charges, transfer charges, electricity duty and banking charges for the use of renewable energy for 14 years	• 100% exemption/reimbursement of cross subsidy surcharge & additional surcharge, STU charges - for 20 years, 25% Wheeling exempt-15 years
7	**Electricity Duty**	• -	• 100% exemption for 7 years	• 100% exemption for 20 years
8	**Employment Generation Subsidy**	• 50 % reimbursement of employer's contribution to EPF and ESI	• Reimbursement of 50% of employer's contribution towards EPF and ESI, for 7 years	• 100% reimbursement of employer contribution towards ESI and EPF for 7 years
9	**R&D**	• 30 % one-time grant support for technology acquisition upto maximum of 5 crores for R&D centres and industries	• One-time grant of upto 30% of cost incurred in the establishment of R&D Centres subject to a maximum of INR 5 Crores	-

International policy level developments in the steel segment

1. China – responsible for producing well over half of the world's steel in 2020 – has announced it will be putting a price on steel emissions, possibly as soon as 2023. They further announced as part of the 14th Five-Year-Plan (2021-2025) that it will be prioritising the creation of a circular economy, seeking to increase the use of scrap steel to 320 million tonnes by 2025, an increase of around 30% relative to estimates for 2020.
2. The European Union is in the process of developing a carbon border adjustment mechanism for steel, while the United States has announced that it is considering the same. These policies would apply tariffs on imported emissions-intensive goods from jurisdictions with weak or absent emissions policy in an effort to limit carbon leakage and incentivise stronger emissions measures overseas.
3. France and Japan recently released roadmaps for decarbonising the iron and steel sector, setting out specific targets and laying out concrete steps for their steel sectors, with the French plan calling for emission reductions of 31% by 2030
4. Germany announced it was earmarking EUR 7 billion for green hydrogen, including EUR 55 million for

Support the industries in transition to renewable energy

In continuation of the above point, it must be noted that State Government has notified the RE Policy to support this transition for industries. The Odisha RE Policy 2022 acknowledges the importance of shifting industries with captive thermal power plants to renewable energy. Accordingly, a number of incentives such as exemptions of Electricity Duty, Wheeling Charges, STU, Cross-subsidy surcharge etc. have been provided. The policy also focuses on easing procedures for land registration, pollution clearances etc. to fast-track project development in the State. The State must focus on implementation of this policy and provide positive signals to industries through the following measures:

Translating RE Policy into ground action

The State must focus on the following to kickstart the RE policy implementation:

1. Undertake potential assessment studies for ground solar, onshore wind, floating solar, offshore wind, hydro, pumped storage, off-river PSP etc.
2. Showcase a list of projects in the State which can be taken up for development
3. Undertake roadshows for the developers to undertake detailed feasibility assessment studies

Demand aggregation for RE power and alternate fuels such as hydrogen, biofuels etc.:

The State Government, through a nodal agency, can aggregate demand from industries for renewable power and also for other fuels such as green hydrogen, biomass etc. The nodal agency can undertake bid process for procurement and onward supply to industries. For this purpose, the standard bidding documents including Request for Proposal, Purchase Agreement, Sale Agreement need to be drafted. For renewable power, such aggregation is already being done in the country through SECI. Thus, standard bidding documents are already in place. For new fuels such as green hydrogen, biomass etc. the State Government can publish a consultation paper outlining the approach for aggregation and the key features of bidding framework. Industries may be asked to provide their comments. Industries can also be asked to furnish the details of their expected demand.

Replicating success of demand aggregation in RE to green hydrogen and other clean fuels

The concept of demand aggregation has been successful at the central level. Solar Energy Corporation of India, as the nodal agency, has worked on demand aggregation for renewable power which has led to rapid increase in renewable capacity in the country. Standard guidelines and bidding documents have provided clarity to procurers as well as project developers. SECI is now planning to launch tenders for green hydrogen aggregation. Demand aggregation is also one of the key demand-side measures emphasized in the National Green Hydrogen Mission

Develop renewable energy and green hydrogen parks

Industries in Odisha are clustered around certain regions such as Angul, Paradeep, Jharsuguda etc. The State can develop renewable energy and green hydrogen parks around these areas. This will be similar to the solar park model where the developers have to come and set-up the plant. All other supporting infrastructure such as power evacuation system, approach roads, park maintenance etc. is done by a Government agency. It is in a way a plug-and-play model. This model has been successful in solar segment.

Hydrogen clusters planned in other States

Kandla Port in Gujarat is planning to develop a green hydrogen park which will provide common infrastructure facilities for private players looking to invest in green hydrogen production. A EOI was floated in response to which 10 companies have shown interest. Through this green hydrogen production close to the port, the Government plans to push for green shipping. Kandla Port on West Coast and Tuticorin port on the east coast have been planned to be developed as green shipping hubs

Developing supporting infrastructure such as power evacuation infrastructure, hydrogen transport, storage

Adoption of clean energy technologies by industries can be supported by developing associated infrastructure such as power transmission systems, storage and transport of fuels, land parcels with basic infrastructure such as water, electricity etc. It is important that such infrastructure be prepared in advance which can then help the investors in taking appropriate investment decisions.

Developing supply chains for clean fuels such as biomass and aggregating industrial demand

The State can also play an active role in developing supply chains for clean fuels such as biomass. For example, as the State is rich in rice production, rice straw based biomass fuels can be sourced by the State in a centralised manner and a supply chain involving processing, storage and distribution can be set up for assured supply to industries. This can be supplied to industries for blending in their captive power plants.

Green Mining

Odisha is a resource-rich State. Mining is one of the major economic activities. Mining is energy intensive as it involves use of heavy machinery. It impacts environment due to loss of forest land. Green mining therefore has to be a key priority for the State. Use of electric vehicles, afforestation, use of renewable energy sources are some of the key initiatives related to green mining. A case for energy transition of OMC, a large State PSU in mining sector is described below:

Opportunity to lead from front in green mining - Odisha Mining Corporation

OMC is largest State PSUs in India's mining sector in terms of quantity of mined material.

A review of OMC's energy consumption profile shows that diesel forms a large part of the energy mix.

Energy source	Consumption – FY 21	Consumption – FY 22
Diesel	31.65 (54%)	52.24 (55%)
Electricity from grid	24.89 (42%)	40.39 (42%)
Electricity from RE sources	2.38 (4%)	2.74 (3%)
Total	58.92	95.37

(Values in TJ; % values show the % of total)

It can be observed that more than 50% of OMC's energy consumption is in the form of diesel. 45% of energy is consumed in the form of electricity. The share of renewable energy in total electricity consumption is low. OMC's installed renewable capacity as of FY 2022 stood at 1.35 MW.

Hybrid diesel electric and battery operated equipment for mining

Electric vehicles are critical to mining reaching net zero, with diesel vehicles accounting for 30%-50% of greenhouse emissions at a mine site. As miners attempt to cut their overall $C0_2$ emissions, the market for Battery Electric Vehicles (BEVs) within the mining sector has proliferated. BEVs are now considered proven technology. This is particularly the case for underground mines, where battery-powered load, haul, dump vehicles are becoming more common.

Several OEMs have launched hybrid diesel and battery operated mining machinery. In India, Hindustan Zinc has announced an ambitious plan to replace diesel with battery operated vehicles.

De-diesalization of mining – Plans of Hindustan Zinc

Vedanta Group company Hindustan Zinc Limited has announced plans of converting its diesel-run 900-odd mining vehicles into battery-operated ones over the next five years. It is working in collaboration with Finnish technology company Normet Group Oy for deploying battery-powered service equipment and vehicles in the mining fleet. USD 1 billion investment has been earmarked for this transition

Repurposing closed mines for closed loop PSPs

Once the mining activity is completed, the closed mines maybe repurposed to be used for closed loop pumped storage projects. Recently, Ministry of Power, Govt. of India has issued guidelines on closed loop PSPs. As per the guidelines, such projects may be allowed to be developed by the private sector on nomination basis.

Establishing standards and creating awareness

Some of the clean energy options such as green cement, green hydrogen etc. are in nascent stages. Government needs to ensure that proper standards defined to evaluate and certify these products as green. As such standards are typically applied nation-wide and need to comply with international standards, the State Government can engage with the Central Government. It is understood that BIS is also working on developing standards for new types of green and sustainable products.

Further, awareness campaigns may be important to increase adoption of such green products. For example, green cement is currently available in the market but lack of consumer awareness and general perception of high cost of green cement has led to limited demand.

Prioritizing green products in government procurement

The State can consider mandating use of green cement, green steel, green aluminum and such clean products in government projects. The Government can undertake an assessment of current capacity in the market to supply green products and accordingly develop a roadmap which provides for adoption of green products in a phased manner. For example, to start with say 20% of green cement may be mandated for government projects and over

Push for green products through carbon taxes

Globally, there is push towards imposing financial "dis-incentives" on fossil fuels. In Canada and Sweden there is a carbon tax on economic activities using fossil fuels. In India as well, coal cess is imposed. In the EU, CBAM is one of several tax and carbon price reforms initiated by the European

Initiatives in manufacturing green industrial products

Vedanta Aluminium launched low carbon 'green' aluminium brand – Restora, to address the fast-growing global demand for low carbon footprint aluminium, driven by greater climate consciousness. Manufactured using renewable energy, Restora has a greenhouse gas (GHG) emission intensity that is well below 4 tonnes of CO2 equivalent per tonne of aluminium manufactured. 4 tonnes of CO2 /ton of aluminium produced is the global threshold for aluminium to be considered as low carbon footprint aluminium.

a period of time gradually the percentage can be increased. Establishing standards is a pre-requisite for implementing this measure so that there is a common understanding on what qualifies as "green."

Capacity building of stakeholders

Clean energy technologies, business models, pricing models are continuously evolving. It is necessary that the policies and regulations reflect these developments taking place in the market. Therefore, capacity building of stakeholders in the Government Departments, implementing agencies and regulatory bodies is done on continual basis. Detailed training need assessment can help in developing a framework for capacity building.

Research & Development

The State Government can develop an ecosystem for R&D focusing on identifying opportunities for clean energy consumption in industries, undertaking pilot projects in collaboration with industries, undertaking feasibility assessments and commercialization of feasible technologies. Such R&D efforts from the State can complement the R&D being done by the industries. An institute in the State can be identified for leading the R&D efforts.

Key projects currently under development

1. The HYBRIT project in Sweden, which is developing hydrogen-based DRI production. A pilot line began operations in summer 2020, a trial delivery of the first fossil fuel-free steel took place in August 2021, and a pilot hydrogen storage cavern opened in June 2022. The project is aiming to demonstrate the technology at industrial-scale production as early as 2026. Major challenges for full operation are sufficient grid capacity and electricity supply to run the electrolysers, which could be exacerbated by the announcement of another green steel production facility in Sweden, H2 Green Steel. Outside Sweden, other companies are also advancing towards hydrogen DRI development, including a demonstration plant being designed in Hamburg, Germany.

2. The "3D" Carbon Capture pilot in Dunkirk, France, began operations in March 2022, starting with the capture of 0.4 kt per year from BF-based production in the demonstration phase. The aim is to expand this to 1 Mt in 2025 and 10 Mt in 2035.

3. Tata Steel announced that it would pursue hydrogen direct reduced iron at the Ijmuiden plant. Plans are still underway to develop a second large-scale pilot plant (0.5 Mt) employing the HIsarna technology in India, which could open in the 2025-2030 period.

6.4. Transport Sector

Overview of the Sector

Transport sector is one of the key contributors to carbon emissions. Odisha has more than 85 lakh registered motor vehicles as of FY 2020. Nearly 1100 million litres of petrol and 3000 million litres of diesel was consumed in the State in FY 2020. Vehicular emission contributes significantly to carbon emissions. For the State to transition to clean energy, it is imperative to use cleaner fuels in the transport sector. The State has notified an EV policy. The Renewable Energy Policy also focuses on developing clean mobility by powering the EV infrastructure with clean energy sources. At the national level, biofuel blending is also done to reduce the carbon emissions. Transport is also identified as a key sector in India's "Long Term Low Emission Development Strategy (LT-LEDS)" outlined in the recent COP 27 meeting. Against this backdrop, the vision for transport sector has been formulated which focuses on decarbonization through more use of EVs and biofuels. The key is to create the required awareness and supporting infrastructure which can lead to higher adoption of clean technologies in transport sector. Promoting use of bio-fuels in State can also help in boosting rural economy.

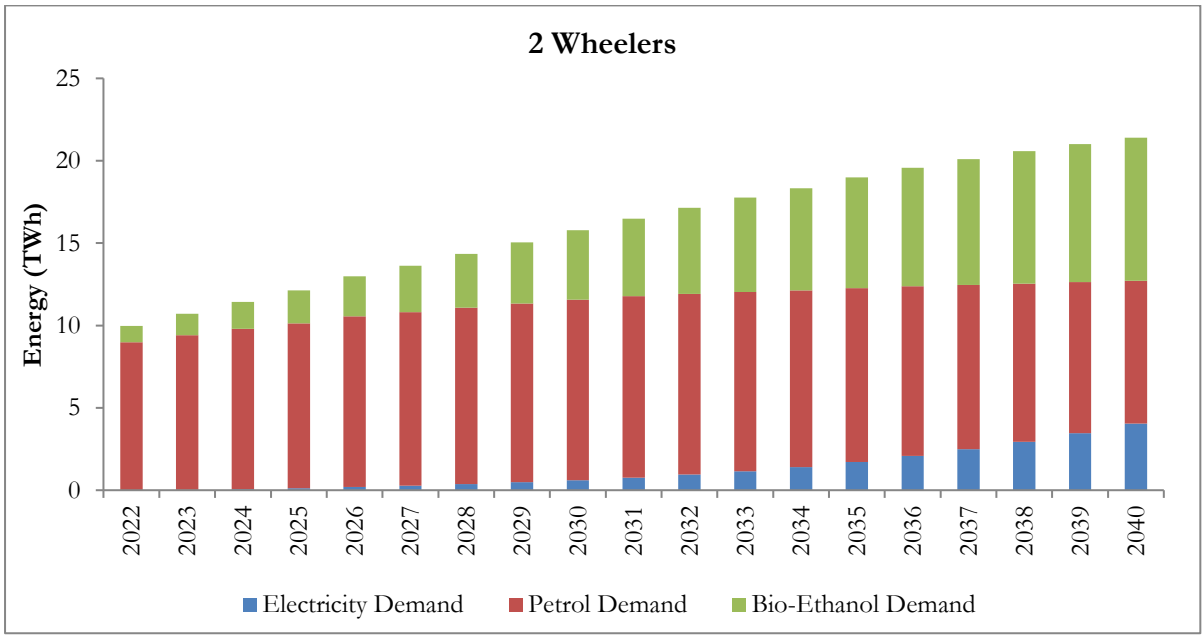
Energy Consumption of Sector

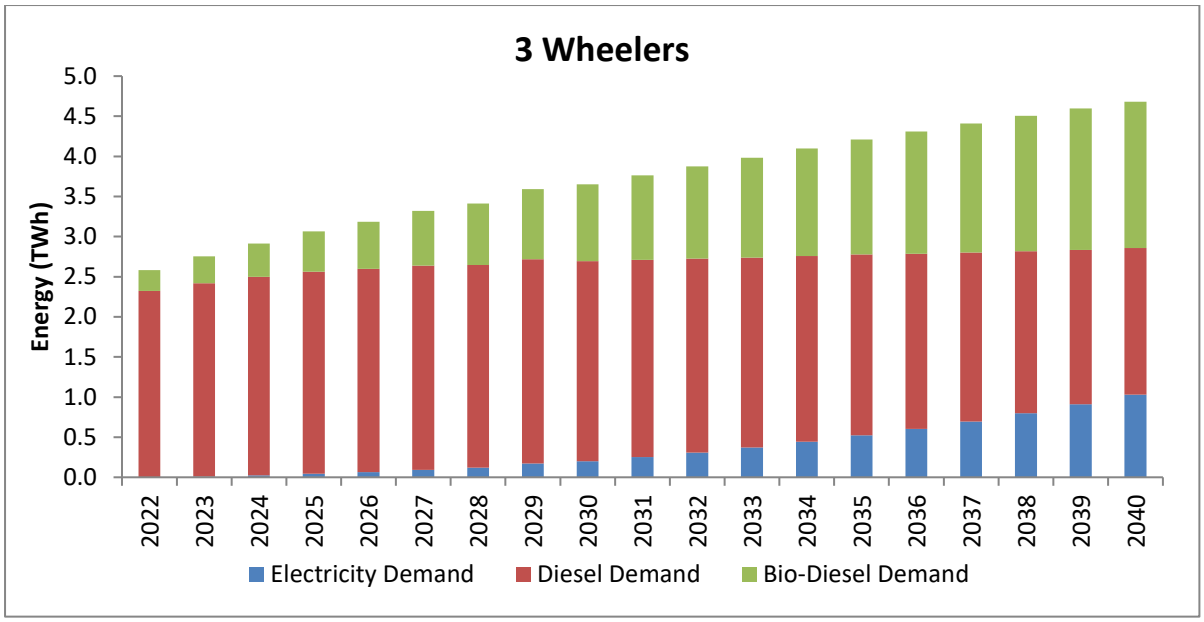
While energy consumption in the transport sector is projected to increase in the upcoming years, the type of energy demand will change with increase in adoption of EVs. The diesel variant vehicles will gradually decline and will be replaced by EVs. There will also be increase in the blending of ethanol and other biofuels.

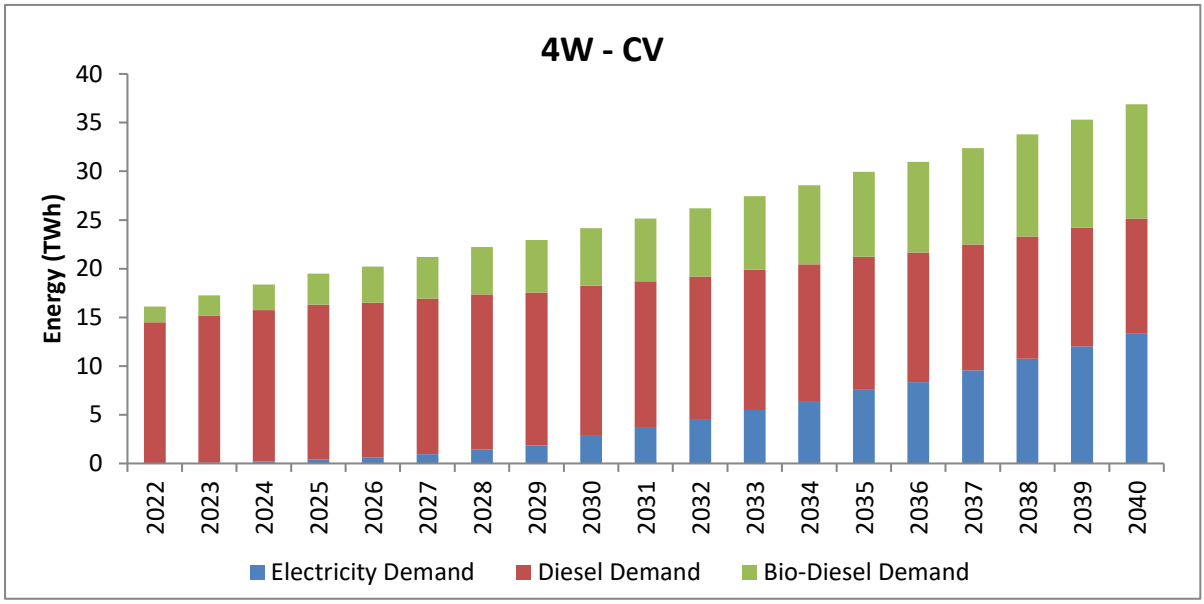
The energy consumption in the transport segment in 2022 is as follows:

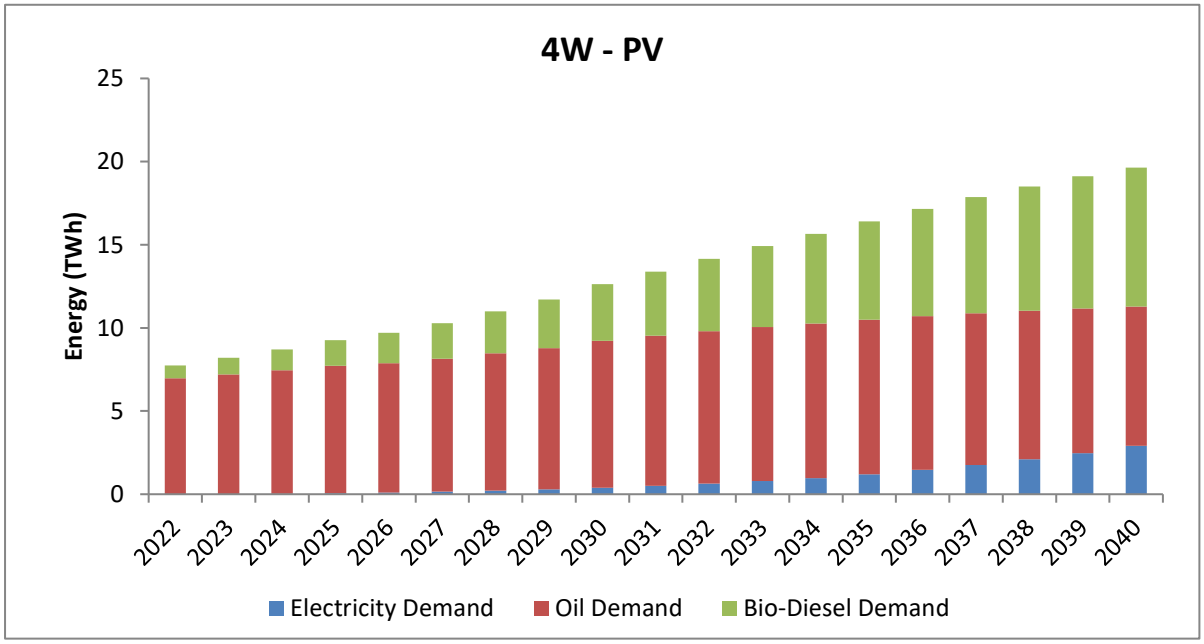
Type	Consumption (TWh)
2-Wheeler	9.98
3-Wheeler	2.58
4-Wheeler Commercial Vehicles	16.11
4-Wheeler Personal Vehicles	7.73
Buses	8.63
Freight	14.07
TOTAL	**59.10**

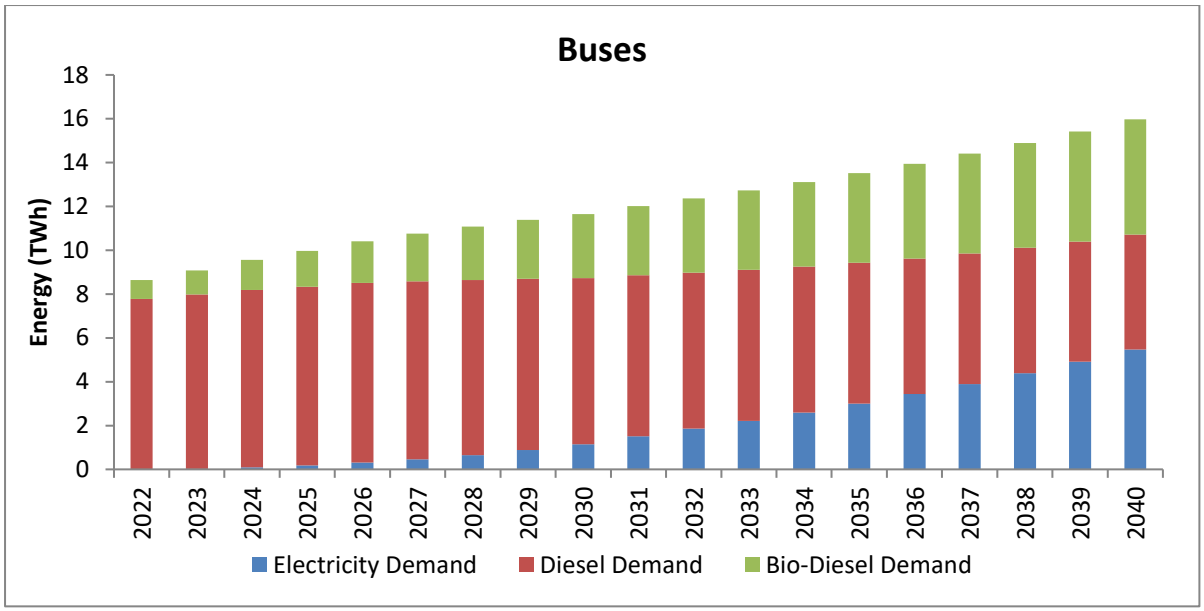
Under the existing policies and state vision, the energy consumption in the transport (passenger and freight) segment shall be as follows:

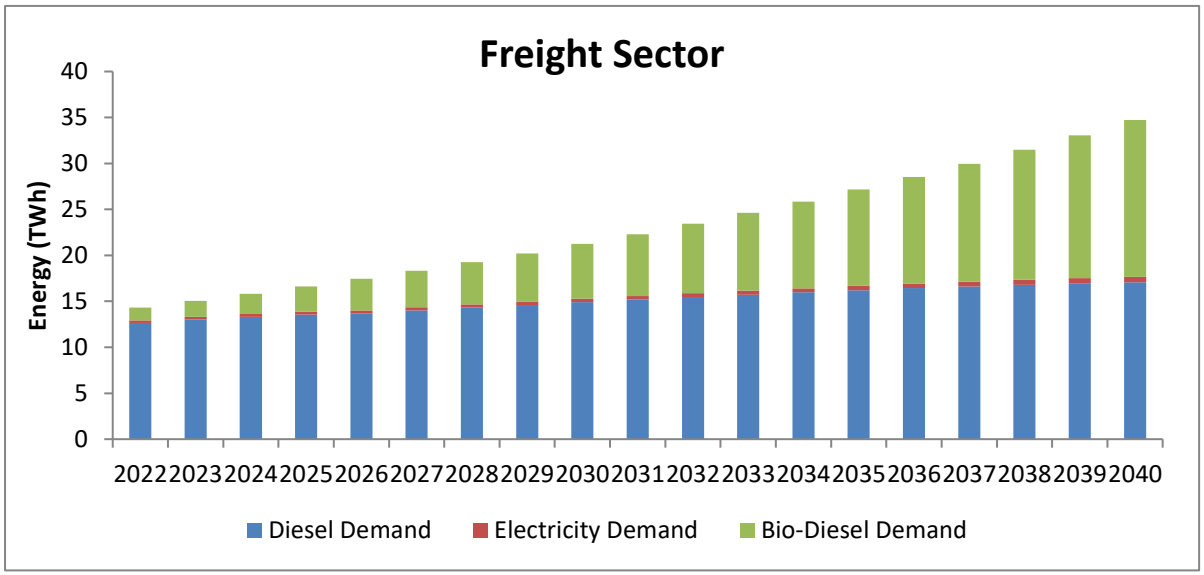



3 Wheelers
Energy (TWh)
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
2022 2023 2024 2025 2026 2027 2028 2029 2030 2031 2032 2033 2034 2035 2036 2037 2038 2039 2040
Electricity Demand
Diesel Demand
Bio-Diesel Demand


4W - CV
Energy (TWh)
40
35
30
25
20
15
10
5
0
2022 2023 2024 2025 2026 2027 2028 2029 2030 2031 2032 2033 2034 2035 2036 2037 2038 2039 2040
Electricity Demand
Diesel Demand
Bio-Diesel Demand


4W - PV
Energy (TWh)
25
20
15
10
5
0
2022 2023 2024 2025 2026 2027 2028 2029 2030 2031 2032 2033 2034 2035 2036 2037 2038 2039 2040
Electricity Demand
Oil Demand
Bio-Diesel Demand





Existing initiatives undertaken in the state

Odisha Electric Vehicle Policy, 2021

Key features of the Odisha Electric Vehicle Policy, 2021 are as follows:

- Achieve adoption of 20% battery electric vehicles in all vehicle registrations by 2025
- 15% subsidy on purchase of electric light motor vehicles and 10% subsidy on purchase of electric buses
- 100% reimbursement of SGST and 100% exemption on road tax & registration fee for electric buses and goods carriages
- SGST reimbursement for EV manufacturing in the State and 25% - 35% capital investment subsidy on plant & machinery
- Government grant up to Rs.5000 for purchase of charging equipment for the first 20,000 charging points
- Building bye-laws shall be made for all new home and workplace to make it EV friendly with additional power load equivalent to the power required for all charging points
- 25 % capital subsidy to Energy Operators for setting up Public Charging Infrastructure

- 100% SGST reimbursement to the Energy Operators on purchase of batteries for public battery swapping stations

Odisha Logistics Policy, 2022

The Odisha Logistics Policy 2022 specifies "Sustainable Development of Logistics Infrastructure" as one of the objectives. As per the policy, the Government shall promote green trucking, green fuels, etc., and adopt sustainable practices towards decarbonising the sector. No specific policy measures are specified for greening the logistics sector.

Vehicle Scrappage Policy of GoI

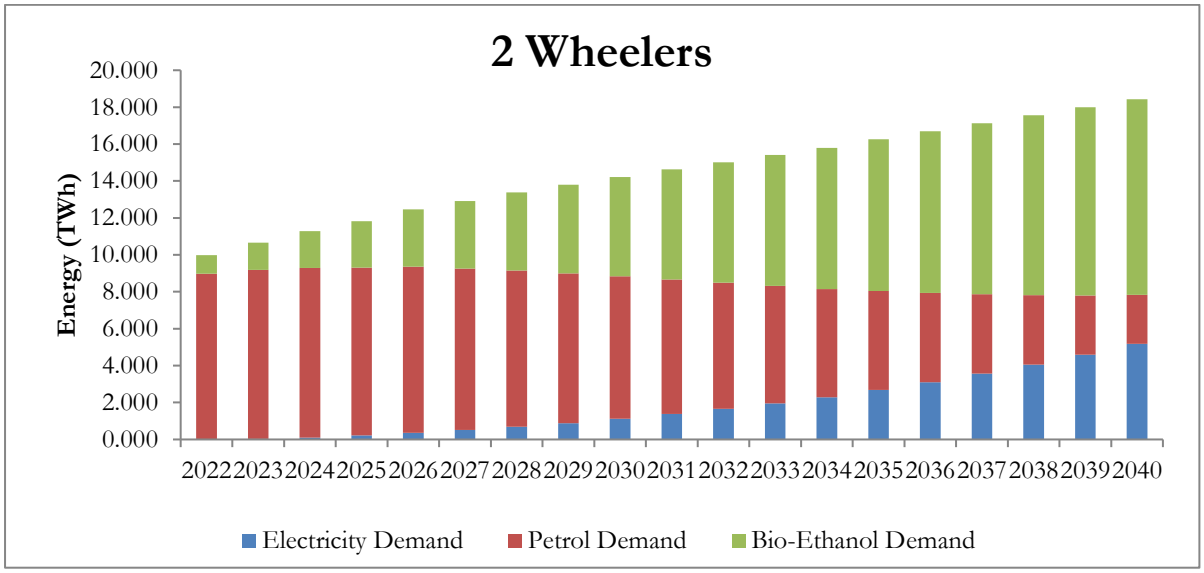
India's Vehicle Scrappage Policy took effect in April 2022. The objective of the government-funded programme is to phase out old passenger and commercial vehicles and thereby reduce urban air pollution, increase passenger and road safety, and stimulate vehicle sales.

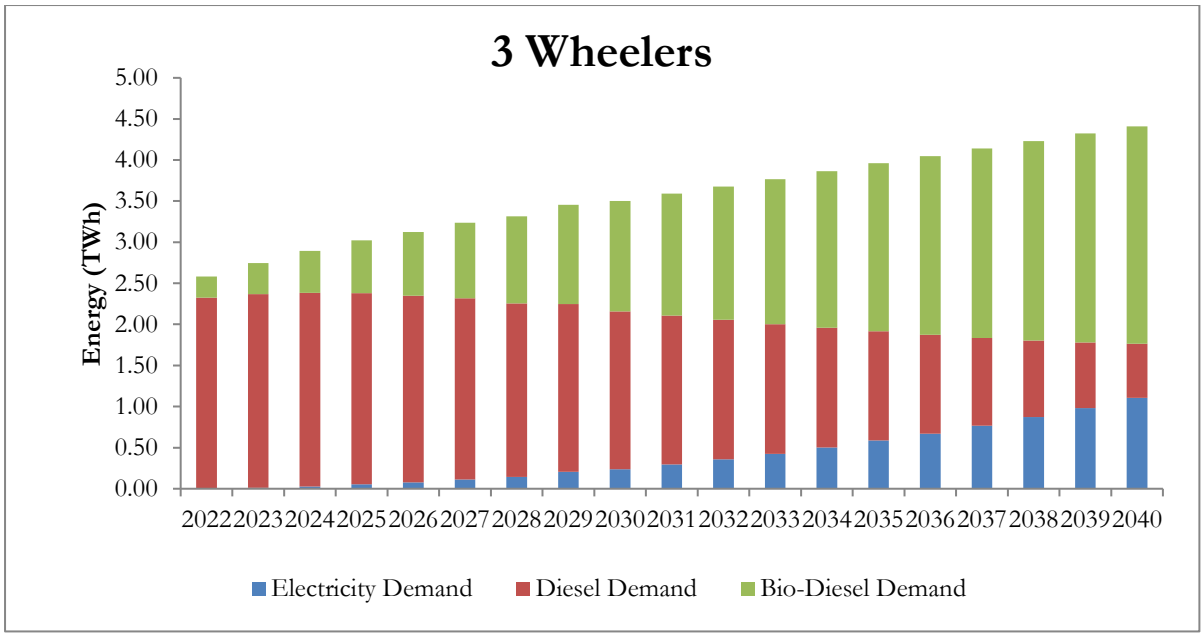
The policy requires passenger vehicles older than 20 years and commercial vehicles older than 15 years to pass a "fitness and emissions test" to keep their registration. Vehicles failing the mandatory test are defined as end-of-life vehicles, lose their registration certificate and are recommended to be scrapped. The policy further introduces incentives to scrap old vehicles, including discounts on the purchase of new vehicles against a scrappage certificate.

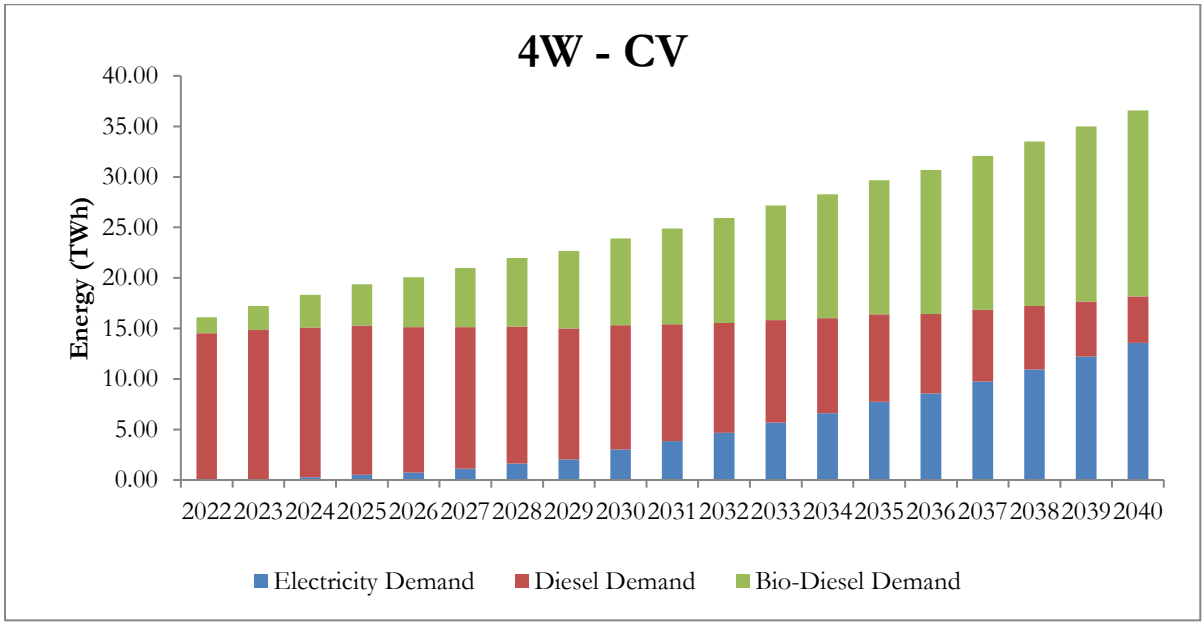
Description of Aggressive Scenario

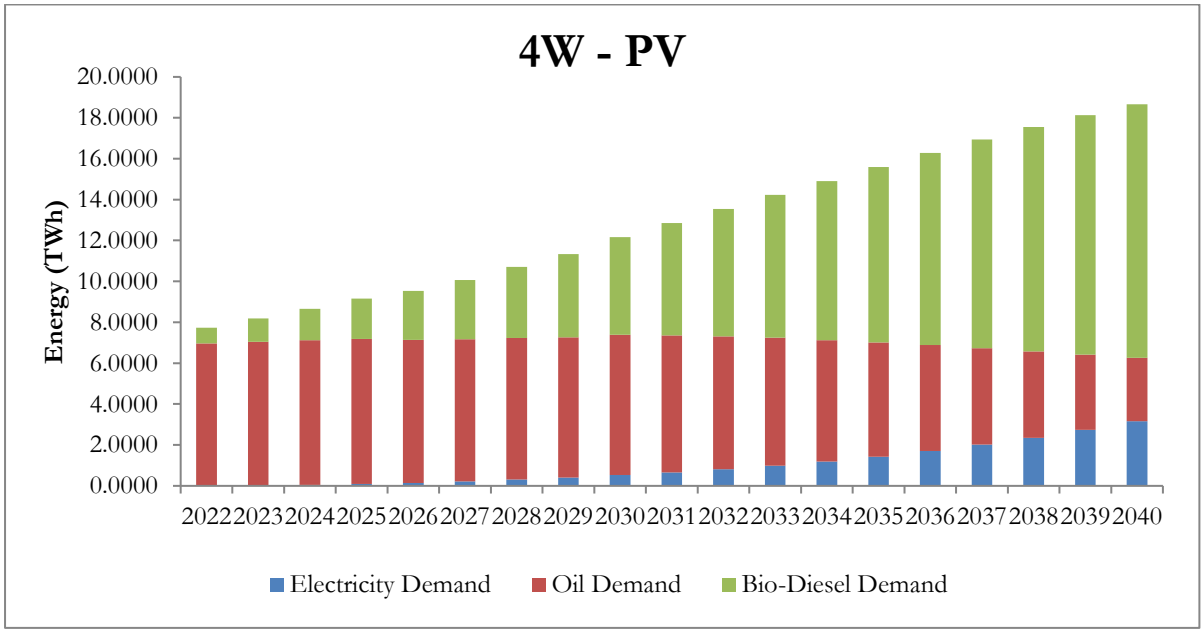
Under aggressive scenario by 2030, all the commercial 4 wheelers and buses will be EVs. The energy demand of the passenger transport is projected to grow at 4.2% CAGR and reach 65.29 TWh by 2030 and 93.91 TWh by 2040. At the same time, the energy demand in the freight category is projected to grow at a CAGR of 4.6%. The demand in the freight category will be primarily driven by diesel vehicles while the amount of blending of biofuels will continue to increase.

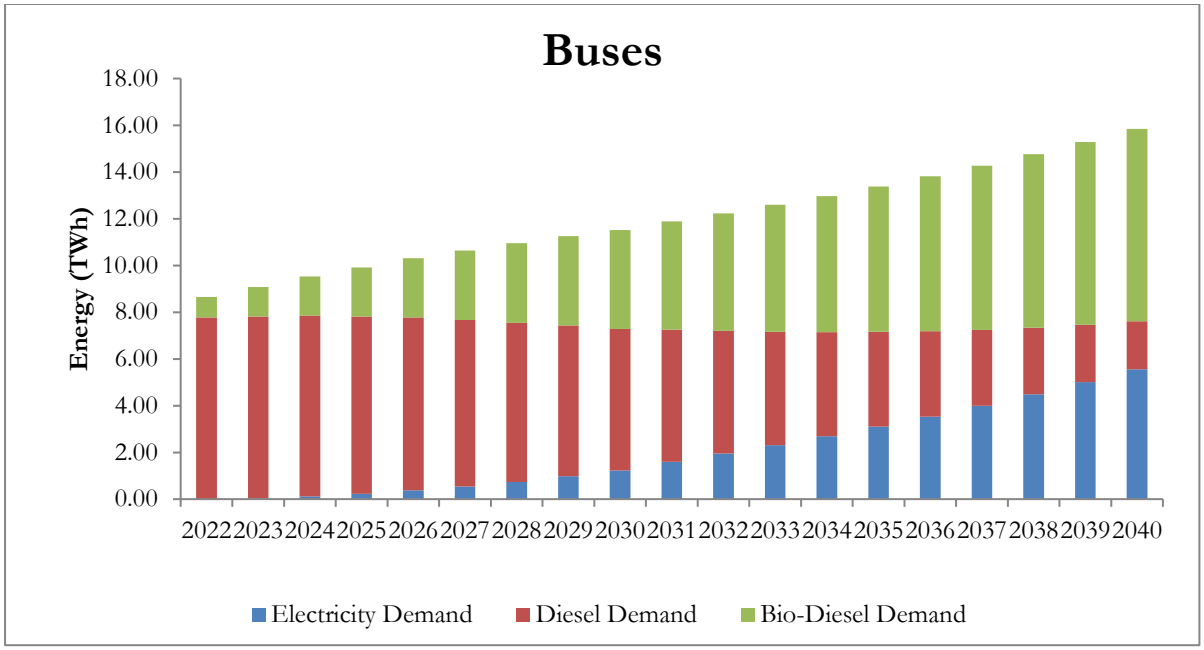
The growth in Energy consumption till 2040 under aggressive scenario is represented in the charts below:

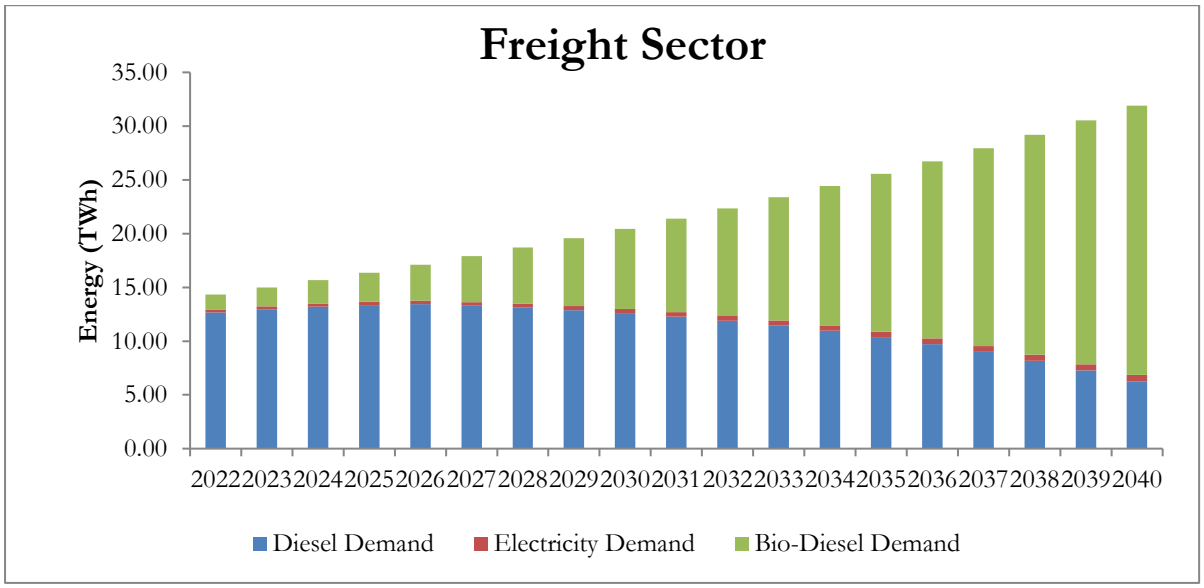



3 Wheelers
Energy (TWh)
5.00
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
2022 2023 2024 2025 2026 2027 2028 2029 2030 2031 2032 2033 2034 2035 2036 2037 2038 2039 2040
Electricity Demand
Diesel Demand
Bio-Diesel Demand


4W - CV
Energy (TWh)
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
2022 2023 2024 2025 2026 2027 2028 2029 2030 2031 2032 2033 2034 2035 2036 2037 2038 2039 2040
Electricity Demand
Diesel Demand
Bio-Diesel Demand


4W - PV
Energy (TWh)
20.0000
18.0000
16.0000
14.0000
12.0000
10.0000
8.0000
6.0000
4.0000
2.0000
0.0000
2022 2023 2024 2025 2026 2027 2028 2029 2030 2031 2032 2033 2034 2035 2036 2037 2038 2039 2040
Electricity Demand
Oil Demand
Bio-Diesel Demand

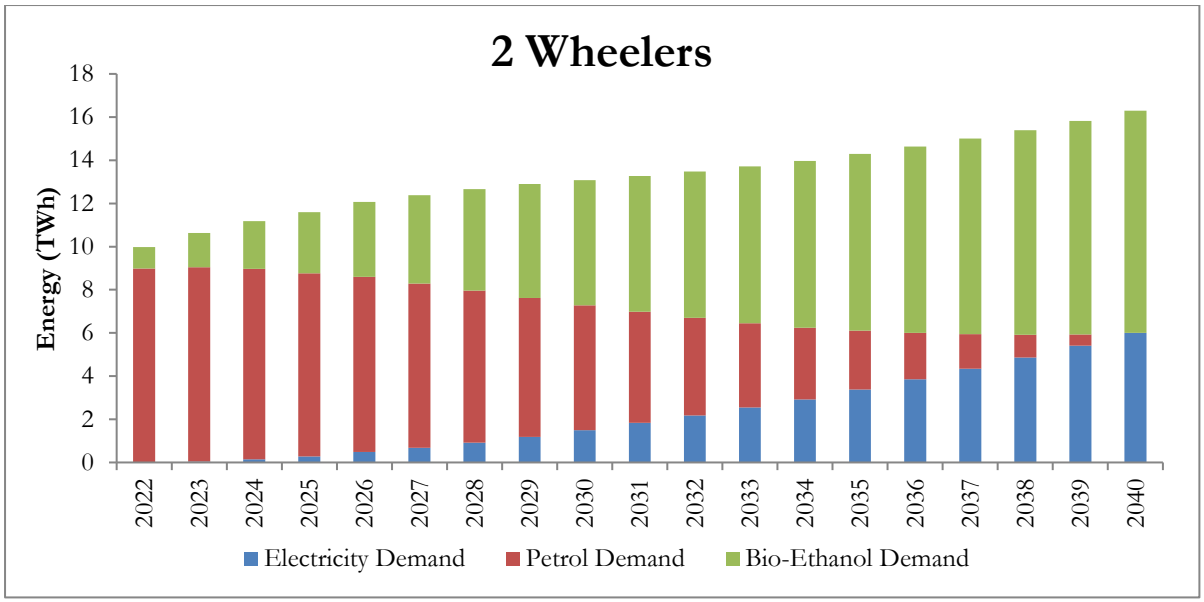




Description of Decarbonisation Scenario

Under decarbonization scenario by 2030, all the commercial 4 wheelers and buses will be EVs. The energy demand of the passenger segment will grow at 3.9% CAGR and reach 63.08 TWh by 2030 and 89.88 TWh by 2040. At the same time, the energy demand in the freight category is projected to grow at a CAGR of 4%. In decarbonization scenario, the mileage of vehicles is considered to be higher, there is higher assumption on the amount of biofuel blending and EV penetration is projected to increase as compared to the baseline and aggressive scenarios.

The growth in Energy consumption till 2040 under decarbonisation scenario is represented in the charts below:


2 Wheelers
Energy (TWh)
0
2
4
6
8
10
12
14
16
18
2022
2023
2024
2025
2026
2027
2028
2029
2030
2031
2032
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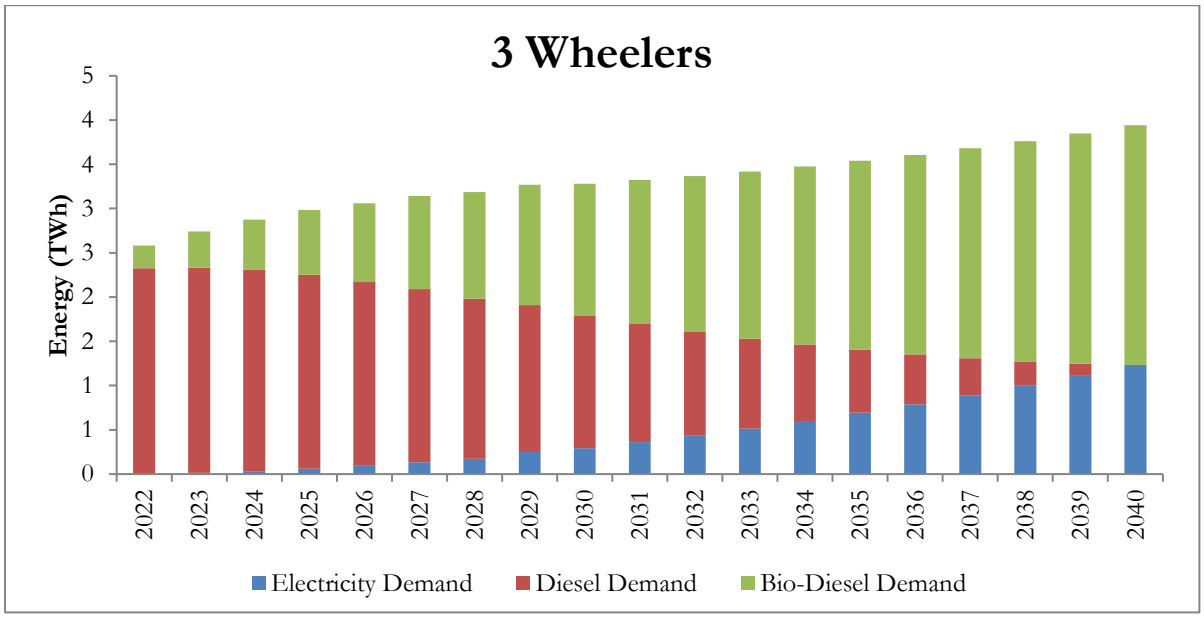
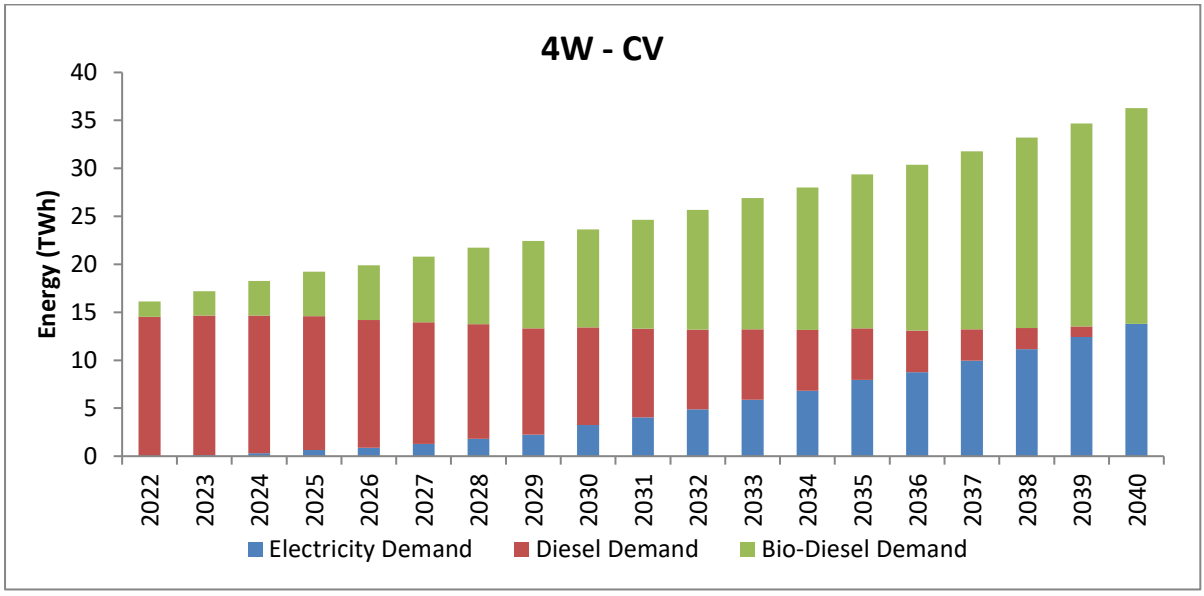
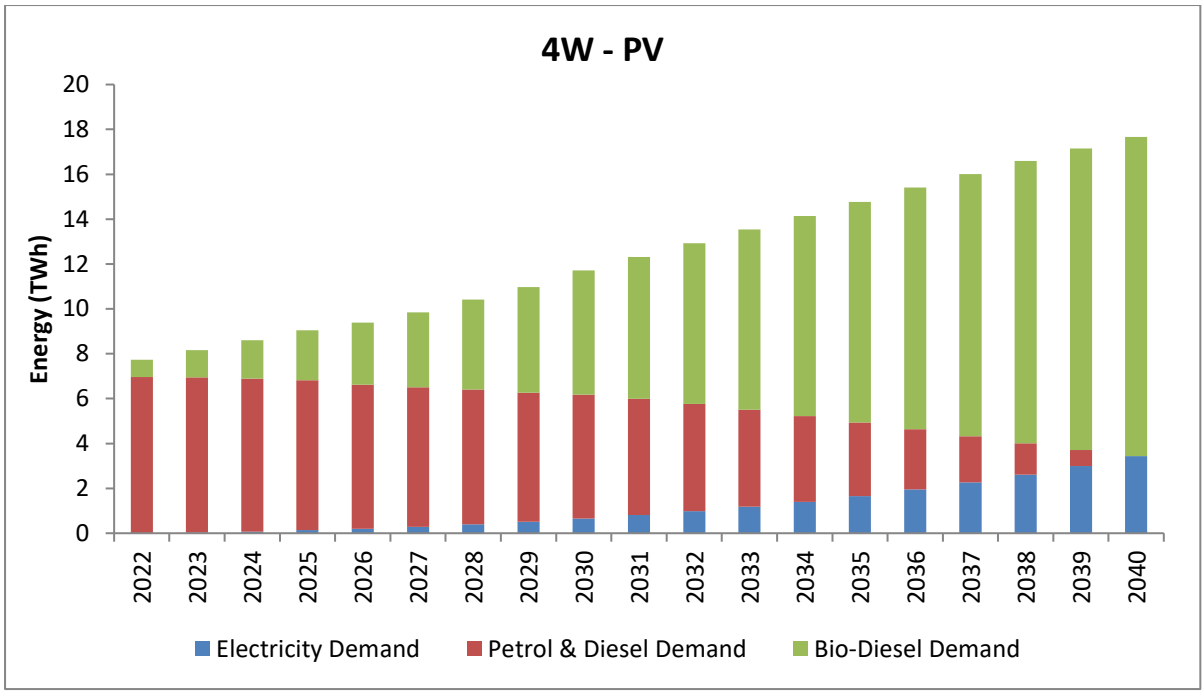
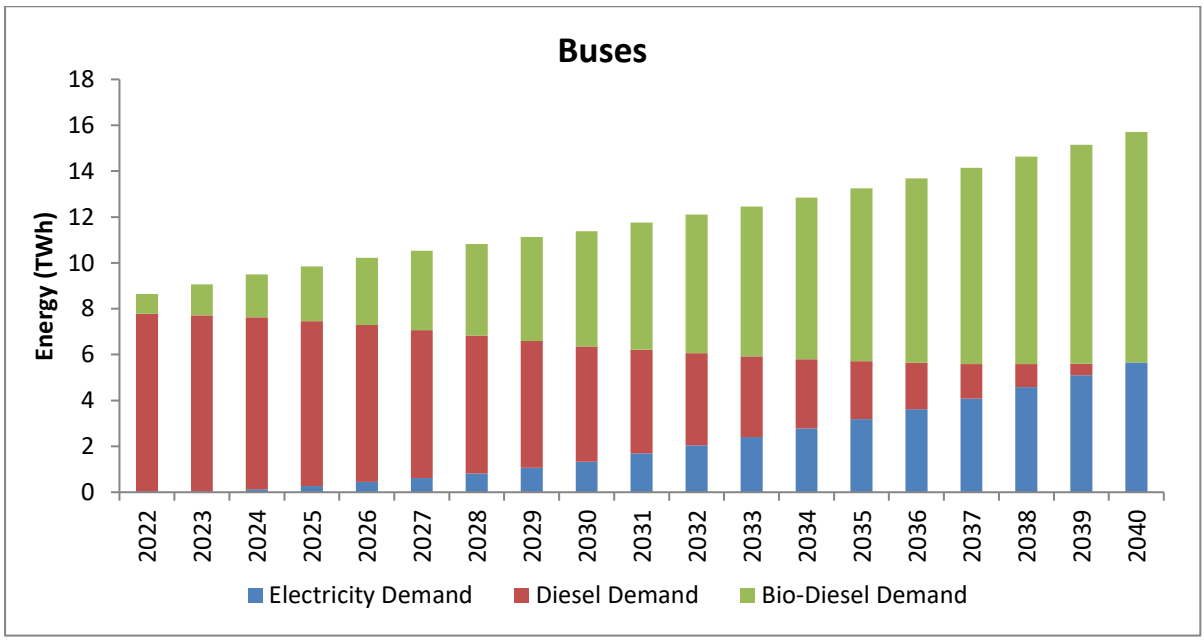
2034
2035
2036
2037
2038
2039
2040
Electricity Demand
Petrol Demand
Bio-Ethanol Demand


3 Wheelers
Energy (TWh)
0
1
1
2
2
3
3
4
4
5
2022
2023
2024
2025
2026
2027
2028
2029
2030
2031
2032
2033
2034
2035
2036
2037
2038
2039
2040
Electricity Demand
Diesel Demand
Bio-Diesel Demand


4W - CV
Energy (TWh)
0
5
10
15
20
25
30
35
40
2022
2023
2024
2025
2026
2027
2028
2029
2030
2031
2032
2033
2034
2035
2036
2037
2038
2039
2040
Electricity Demand
Diesel Demand
Bio-Diesel Demand


4W - PV
Energy (TWh)
0
2
4
6
8
10
12
14
16
18
20
2022
2023
2024
2025
2026
2027
2028
2029
2030
2031
2032
2033
2034
2035
2036
2037
2038
2039
2040
Electricity Demand
Petrol & Diesel Demand
Bio-Diesel Demand


Buses
Energy (TWh)
0
2
4
6
8
10
12
14
16
18
2022
2023
2024
2025
2026
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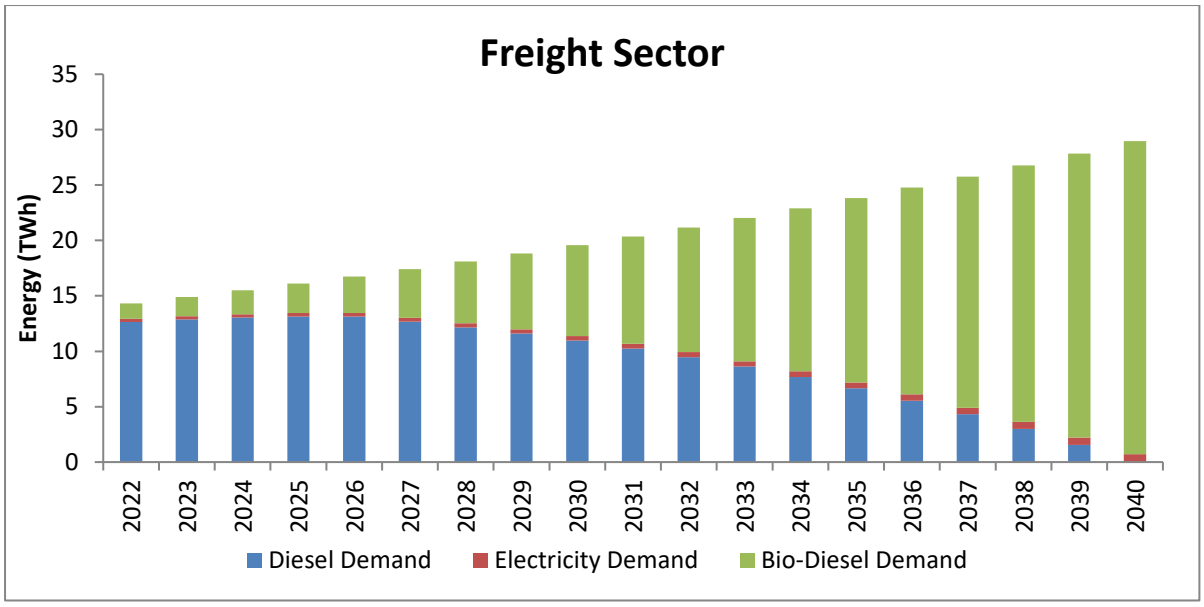
Electricity Demand
Diesel Demand
Bio-Diesel Demand



Sectoral Vision

The approved vision from the Transport Department is provided below along with the other views of the Department.

Vision Statement: State shall ensure shift to cleaner fuels in transport for a positive impact on climate

- **Objective 1:** Support development of electric vehicle ecosystem such as charging infrastructure, battery swapping stations etc. and ensure 50% of all new sales to be electric by 2030 through effective co-ordination across departments. Target to set-up public charging infrastructure with atleast one charging station in every 3km x 3 km grid area. Atleast one charging station in every 25 km on both sides of highways/roads. Fast charging stations for heavy trucks at every 100 kms on both sides of highways.[12]
- **Objective 2:** Convert 100% of government fleet to electric by 2027 and develop charging infrastructure at government offices
- **Objective 3:** Convert all intra-city buses to electric by 2027 and maximise penetration of electric buses in inter-city transport
- **Objective 4:** Ensure development of renewable based charging infrastructure

Department views on vision

1. Odisha EV policy has set a target of 20% EV registrations by end of 2025. By end of 2022, only 4.48% of EV registration has been seen. Considering the shortfall in targets, the incentives have been revised.
2. All Government vehicles exceeding age of 15 have to be scrapped as per the Odisha Vehicle Scrapping Policy. All Departments have been requested to replace atleast 20% of vehicles running on lease rental to be replaced by EVs.
3. Department has set a timeline of rolling out an EV strategy in Government offices in all municipalities by 31-Dec-2024, in all non-urban areas by 31-Dec-2025 and in all remote areas by 31-Dec-2027.
4. Under the scheme Location Accessible Multimodal Initiative, the Government has planned for 20% of buses to be electric by 31-Mar-2024.

- **Objective 5**: Increase use of biofuels and target 20% ethanol blending by 2025-26[13]
- **Objective 6:** Increase use of green hydrogen as vehicle fuel to drive low carbon development of transport sector in the state[14]

[12] As per the Ministry of Power "Charging Infrastructure For Electric Vehicles - Guidelines and Standards" notified on 14.01.2022
[13] As per Ethanol Blended Programme (EBP) and National Policy on Biofuels of Government of India
[14] Based on India's COP27 long-term low emission development strategy

- **Objective 7:** Create large scale Public awareness campaigns and earmark a budget for RE based EV promotion in State
- **Objective 8:** Focus on developing multi-modal public transport with less polluting modes of transport. Integrate transport with urban planning and multi-modal connectivity.

Action Plan

Transport sector is an enabling sector that connects people and communities with jobs, education, healthcare and enables efficient logistics chains of delivering goods and services so thereby ensuring a just and equitable socioeconomic growth. Transport sector is among the largest contributors of greenhouse emissions. There is a need to transform transport and make it more sustainable so that the mobility needs of the present and future generations can be catered with least damage to the environment.

The following action plans can contribute to make transport eco-friendly by reducing the environmental impact arising out of usage of petrol/diesel vehicles.

1. Promotion of Electric Vehicles (EVs)

The most immediate step that can be taken to decarbonize transport is to promote EVs through suitable incentive mechanism so as to bridge the differential between ICE vehicles and EVs thereby reducing the switching costs. The incentives may range from direct purchase subsidies to indirect benefits like registration fee rebates. The Odisha EV policy

Focus on shifting government fleet to EV: Government department and agencies can be the early adopters by substituting the diesel/ petrol vehicles by EVs. OREDA has recently kickstarted the process by solicitating bids for acquiring 300 EVs. The same may be expanded in subsequent phases to replace all government vehicles with EVs by 2027.

Public awareness campaigns: The government may also take initiatives to promote usage of EVs through public awareness campaigns. State Government may organize roadshows to create awareness on the environmental consequences of using petrol/diesel vehicles. Major EV players may be invited to the roadshows to educate citizens on benefits of EVs and allow them to experience the benefits first hand. The State already runs a GoEV campaign which may be scaled up.

2. Developing charging infrastructure to support EVs

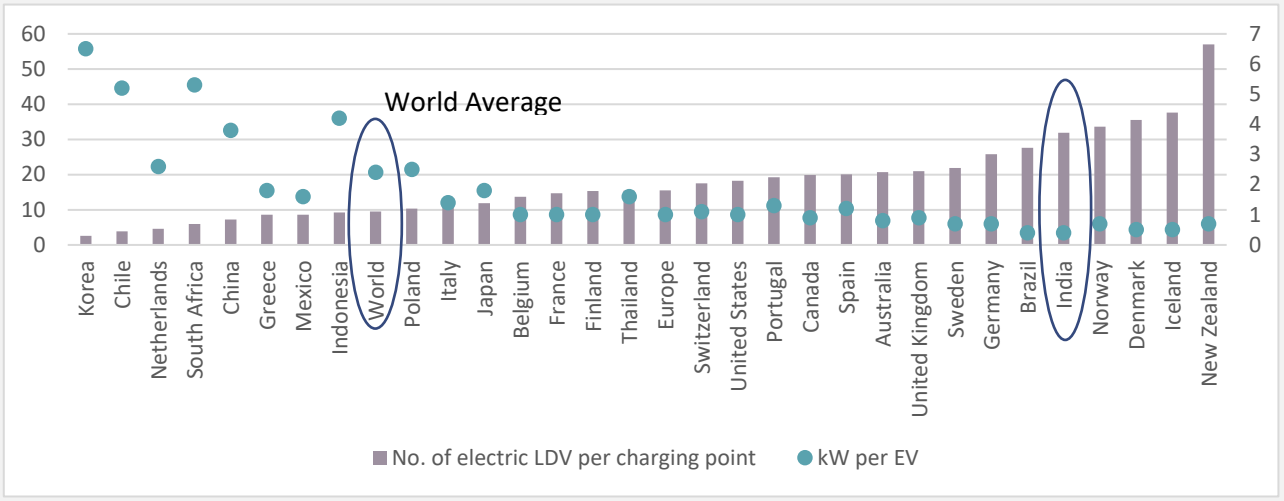
Ministry of Power has issued guidelines for charging infrastructure for vehicles. The guidelines have the following provisions with respect to density of charging points:

i. At least one charging station in a grid of 3x3 km
ii. Once charging station must be located every 25 km on both sides of highway
iii. For long range EVs and heavy vehicles, atleast one fast charging station shall be located every 100 kms on each side of the road
iv. Within cities, charging facilities for heavy duty EVs may be located at bus depots

The State Government may prepare a plan for developing charging infrastructure meeting the above requirements. Cities/districts may be prioritized based on size of population, vehicle density etc.

NITI Aayog has outlined three models for development of charging infrastructure – government-driven model, consumer-driven model and service provider model.

Global situation : Number of light duty EVs per charging point and kW of charging power per light EV



The chart above shows that Korea has highest density of charging points – 2.6 EVs per charging point. Compared to this, India has 32 EVs per charging point. The kW per EV metric is important since fast chargers can serve a higher number of EVs compared to slow chargers.

3. Develop infrastructure for CBG use in vehicles

CBG can be used in vehicles as a fuel. As per the FAQs issued by IOCL, CBG has properties almost similar to CNG and hence a vehicle running on CNG can straightway be filled with CBG without any modification in the vehicle. Ministry of Road Transport and Highways, Government of India, vide Gazette Notification no. 395 dated 16.6.2015 has permitted usage of CBG for motor vehicles as an alternate of CNG. BIS has issued IS 16087 2016 standards on CBG which is similar to BIS specifications IS 15958:2012 for CNG.

The State Government can encourage development of supply chain for biomass and other sources used for production of CBG. CBG plants may be encouraged. Reserve Bank of India has notified inclusion of CBG projects under Priority Sector Lending vide directives to Banks dated 4.9.2020. Ministry of New and Renewable Energy has extended Central Financial Assistance (CFA) Scheme on CBG. State Bank of India and Bank of Baroda have launched products for financing of CBG Plants.

4. RE powered charging infrastructure

Deploying battery operated electric vehicles is only a part of the decarbonisation journey. It is also essential to ensure that the charging infrastructure uses renewable energy for battery charging. The State Government can plan to develop solar based charging facilities around major bus depots.

5. RE powered public transport infrastructure

The State Government can plan to develop solar powered bus depots. Cities such as Varanasi and Chennai have made such plans.

Solar powered bus stations

In Varanasi, a smart bus station powered by solar power was inaugurated in Nov-2022. It was part of Varanasi Smart City program.

In Chennai, the Chennai Metropolitan Development Authority, got a study done to make Madhavaram Mofussil Bus Terminus a net zero bus station. It was planned as a "on-grid" solar power system to facilitate sale to grid under net metering.

Case Study: RE Powered Delhi Metro

At present, Delhi Metro Rail Corporation (DMRC) receives 35 per cent of its total energy supply from renewable energy sources and aims to increase the share to 50% by 2031. 30% of DMRC's power is sourced from REWA solar power plant in Madhya Pradesh, 4% from its 142 rooftop solar installations and 1% from the Waste-to-Energy plant in Ghazipur.

6. Incentive to scrap old vehicles

Old, unfit, and ill-maintained vehicles are one of the prime contributors to greenhouse emission. The Vehicle Scrappage Policy was introduced in India in 2021 to mitigate this problem. The idea behind the scrappage policy is to gradually develop an ecosystem that phases out vehicles contributing to pollution. The vehicle scrappage policy nullifies the re-registration of cars that are above 20 years old. For commercial vehicles, the threshold is 15 years as they face extensive and heavy usage compared to personal vehicles. Incentives are also being offered in the form of road tax concessions and discounts on purchase of new vehicles. The State Government may provide additional benefits for quick phase out of old, unfit vehicles and replace them EVs. State Government may also tie up with financial institutions to provide loans at discounted rates to vehicle owners who voluntarily turn in their old vehicles before they are scrapped and switch to EVs.

Case Study: Egypt Vehicle Scrapping and Recycling Program

In Egypt, Vehicle Scrapping and Recycling Program encouraged taxi drivers to voluntarily renounce their old, polluting vehicles for managed scrapping and recycling in exchange for new, more environmentally friendly vehicles. The new taxis were purchased from pre-registered vehicle dealers at a discounted price and with financing facilities. By the end of 2018, around 45,000 taxis had been turned in, scrapped, and recycled in Cairo alone, resulting in emission reductions of approximately 350,000 tonnes (World Bank, 2018).

7. Focus on transitioning 3-wheeler vehicles to EVs

3-wheeler vehicles are mostly likely to be the earliest to transition to 100% EVs. These vehicles have to travel fewer distances, carry more load and generally will sufficiently work with a day's worth of charge. Growth in e-commerce will be a key driver for the growth of electric three-wheelers in the market. The increased demand for last-mile connectivity for the better and fast delivery of goods will lead to the growth of electric three-wheeler vehicles. The preference for electric three-wheelers in this regard is growing as they offer the ease of navigating through narrow streets with limited load capacity. Due to these benefits, there has been an increase in the uptake of 3-wheeler EVs. Odisha must try to utilize this momentum and offer suitable incentives to increase the penetration of EVs in the State.

6.5. Cooking Sector

Overview of Sector

For cooking sector, the **main fuels used are solid hydrocarbons (i.e., coal and biomass), liquid hydrocarbons (i.e., LPG and kerosene), gaseous hydrocarbons (i.e., PNG and biogas) and electricity.**

- Share of biomass in urban and rural households accounts for 19% and 77% in 2001, which reduced to 13% and 57% in 2011.
- There is a growing importance of LPG in the consumption of urban and rural households. Near about 79% of households had LPG connections in FY21
- Domestic PNG connections have grown at a CAGR of 575% in Odisha between FY18 and FY21.

According to NITI Aayog's state ranking (based on 2019-20 data), **Odisha scored 9.2 in terms of clean cooking fuel supply** (**one of the lowest in India**)[15].

- The state has been gradually improving access to modern and clean cooking solutions for the population; however, the progress is slow.
- In the cooking sector, the share of LPG in households accounted for 47% in 2021. This is due to the growing importance of LPG which is reflected in its consumption pattern in urban and rural households i.e., an increase in the number of LPG connections from 4.49 million in 2017 to 8.88 million in 2021.

Odisha had also launched **Improved Cookstove Programme.**

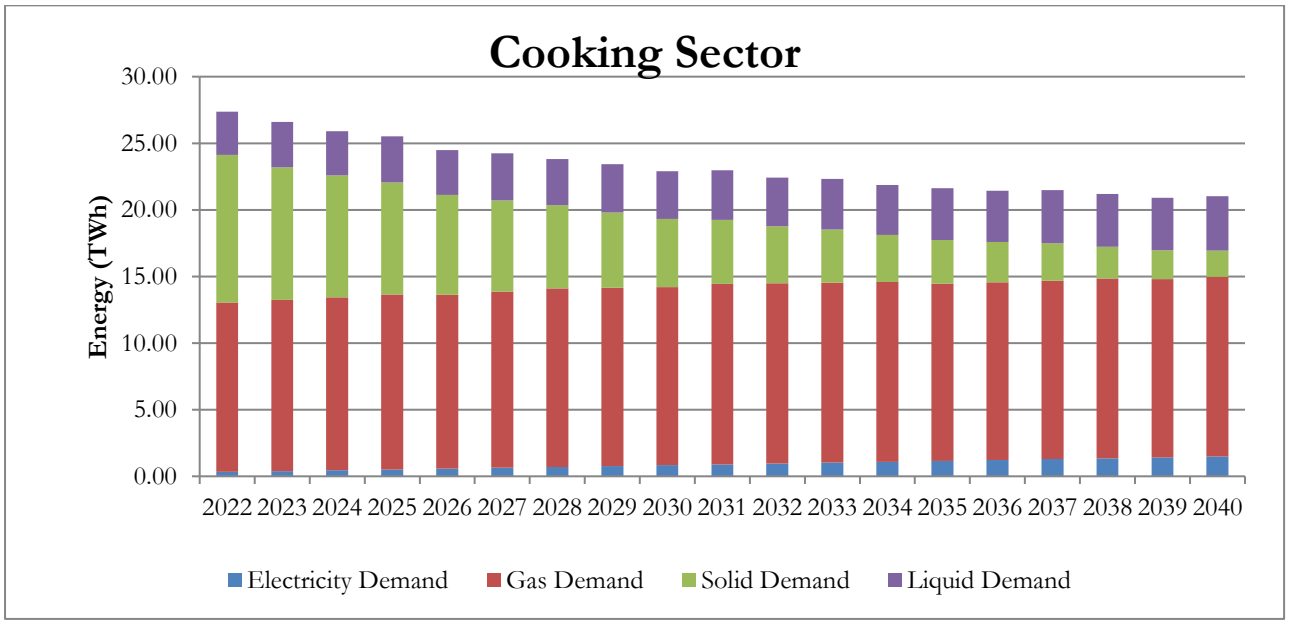
- Under this till 2018-19, 10,754 schools have been provided with improved cook-stoves for cooking mid-day meals and 7,256 portable chullahs have been supplied to DFOs and Range officers for distribution to households in forest/forest fringe villages.
- During 2019-20, 3,257 number of improved cook stoves were distributed as part of the programme.
- Odisha has also installed 239 family family-type biogas plants during FY19 and FY20 to serve the cooking & lighting need of the households.

In terms of **piped natural gas in the domestic sector**:

- There has been an exponential growth from 87 connections in FY18 to 26,790 connections in FY21.
- GAIL (India) Limited and GAIL Gas Limited have been serving these domestic customers in Khordha, Cuttack, Sundargarh, Jharsuguda, Ganjam, Nayagarh & Puri districts.
- From 2023, GAIL India Limited intends to provide PNG to 20,000 additional families in the districts of Khurda and Cuttack, 20,000 more connections will be added annually after this.

Energy Consumption of Sector

Cooking energy in the state is expected to grow at a CAGR of around 0.45% from 15.5 TWh to 16.8 TWh between 2022 and 2040 with the major fuel being LPG while raw biomass gradually phasing out. The figure below presents the energy demand trends in the cooking sector in 2022 and 2040:



[15] https://www.niti.gov.in/sites/default/files/2022-04/StateEnergy-and-ClimateIndexRoundI-10-04-2022.pdf, Accessed on July 26, 2022

Figure 36: Fuel-wise energy consumption in the cooking sector

Energy Consumption of the Sector

The main fuels used in the sector are solid hydrocarbons (i.e., coal and biomass), liquid hydrocarbons (i.e., LPG and kerosene), gaseous hydrocarbons (i.e. PNG and biogas) and electricity. The growing importance of LPG which is reflected in its consumption pattern in urban and rural households i.e., an increase in the number of LPG connections from 4.49 million in 2017 to 8.88 million in 2021.

Existing initiatives undertaken in the state

The initiatives of state and central government that are currently being undertaken w.r.t. cooking sector is given as under:

1. Pradhan Mantri Ujjwala Yojana (PMUY)

In May 2016, Ministry of Petroleum and Natural Gas (MoPNG), introduced the PMUY as a flagship scheme with an objective to make clean cooking fuel such as LPG available to the rural and deprived households which were otherwise using traditional cooking fuels such as firewood, coal, cow-dung cakes etc. Usage of traditional cooking fuels had detrimental impacts on the health of rural women as well as on the environment. The target was to release 8 crore LPG connections to the deprived households by March 2020 (MoPNG 2021).

Under the scheme, the Cabinet Committee on Economic Affairs has approved a subsidy of INR 200 per 14.2 kg cylinder for up to 12 refills per year for the beneficiaries of PMUY with a total expenditure of INR 7,680 crore for 2023-24 (PIB 2023). The scheme has been launched in Odisha in 2016. LPG connections under the scheme in Odisha stood at 52,66,949 up until July 2022 (Press Information Bureau 2022).

2. GOBAR-DHAN scheme

GOBAR-DHAN or Galvanizing Organic Bio-Agro Resources Dhan was launched in 2018, to ensure cleanliness in villages by converting bio-waste including animal waste, kitchen leftovers, crop residue and market waste into biogas and organic manure to improve the lives of villagers. This will provide economic and resource benefits to farmers and households. Department of Drinking Water and Sanitation is working with concerned Departments/ Ministries, state governments, public and private sector institutions and village communities to give this a shape of "Janandolan" so that community collective action on GOBAR-DHAN is achieved (PIB 2018).

3. New National Biogas and Organic Manure Management Programme (NNBOMP)

To promote the installation of biogas plants (1 cu.m. to 25 cu.m. per day), Ministry of New & Renewable Energy (MNRE) implemented NNMOBP scheme under off-grid/ distributed and decentralized renewable power. The objective was to provide clean cooking fuel for kitchen, lighting and meeting other thermal and small power needs of farmers/ dairy farmers/ users including individual households and to improve organic manure system based on bio slurry from biogas plants in rural and semi urban areas by setting up of biogas plants (MNRE 2017). Presently, 2.41 lakh biogas plants have been setup in the state of Odisha (OREDA 2022).

4. Promotion of Electric Cooking

To promote and increase the penetration of electric cooking in the state, Energy Efficiency Services Ltd (EESL) announced it has joined hands with MECS Programme for large-scale deployment of more than 20,000 induction cookstoves and electric pressure cookers in India. The deployment is expected to accelerate the acceptance and large-scale adoption of modern electric cooking devices in Indian kitchens (ET Energyworld 2022).

5. Pradhan Mantri Urja Ganga Project

The Government of India had launched the Pradhan Mantri Urja Ganga gas pipeline project in FY2018 with an aim to provide piped natural gas as a cooking fuel to the households in selected states with Odisha being a part of the scheme (GAIL 2020). Latest statistics shows that in Odisha nearly 4,000 inch Kms of pipeline infrastructure have been laid up until October 2022 (Tathya 2022). In Odisha, the Natural Gas Pipeline will be constructed at an estimated investment of INR 4,000 Crores and will have a length of about 769 km covering 13 districts including Bhadrak, Jajpur, Dhenkanal, Angul, Sundergarh, Sambalpur, Jharsuguda, Debagarh, Jagatsinghpur, Cuttack, Khurda, Puri and Kendrapara (ET Energyworld 2017).

Starting 2017, infrastructure has been created at an investment of INR 250 crore to supply piped gas to 20,000 households in Bhubaneshwar and 10,000 in Cuttack besides, 16 CNG stations since 2017.
From Nalco Nagar, the network has extended to Kalinga Nagar in Bhubaneswar and around 1,400 households were getting PNG in 2021 while the connection for 19,000 families is awaiting approval from the Petroleum and Explosives Safety Organisation (PESO) (The New Indian Express 2021).

Description of Aggressive Scenario (Scenario -3)

Cooking energy in the state is expected to grow at a CAGR of around 0.42% from 15.46 TWh to 16.67 TWh between 2022 and 2040 with the major fuel being LPG while traditional biomass will phase out by 2030 as per the Odisha state energy vision 2030.

Table 32: Energy demand in cooking in Odisha between 2022 and 2040

Particulars	Unit	2022	2025	2030	2035	2040	CAGR (%)
Cooking Energy Demand	TWh	15.46	15.68	16.01	16.24	16.67	0.42

The figure below presents the energy demand trends in the cooking sector in the state between 2022 and 2040:

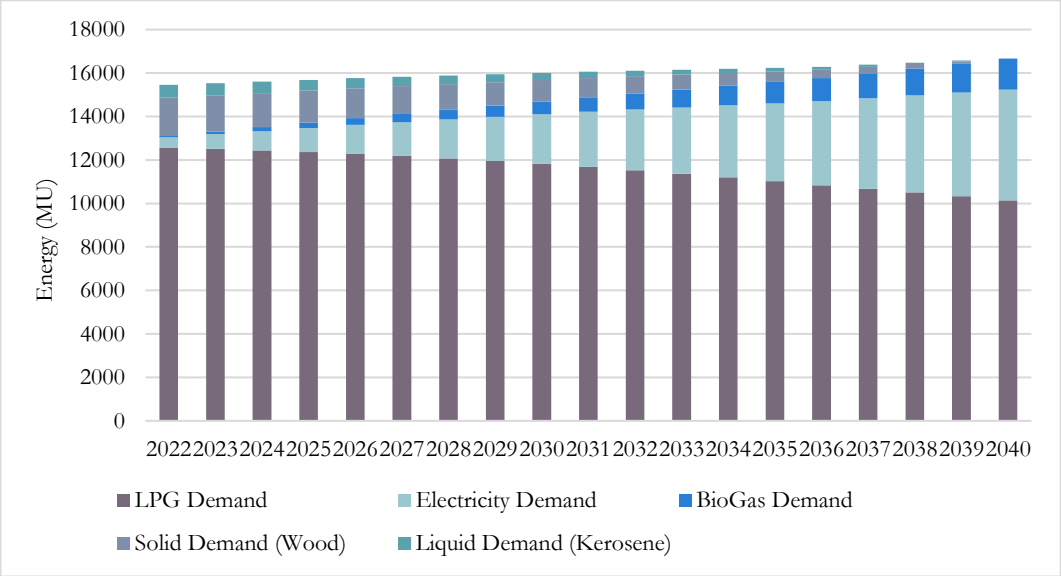


Figure 37: Cooking Energy Consumption between 2022 and 2040

Description of Decarbonization Scenario (Scenario – 4)

Cooking energy in the state is expected to grow at a CAGR of around 0.35% from 15.45 TWh to 16.46 TWh between 2022 and 2040 with the major fuel being electricity whereas traditional biomass will phase out by 2030 as per the Odisha state energy vision 2030. Further, the state will not rely on LPG / PNG.

Table 33: Energy demand in cooking in Odisha between 2022 and 2040

Particulars	Unit	2022	2025	2030	2035	2040	CAGR (%)

Cooking Energy Demand	TWh	15.45	15.65	15.92	16.10	16.46	0.35

The figure below presents the energy demand trends in the cooking sector in the state between 2022 and 2040:

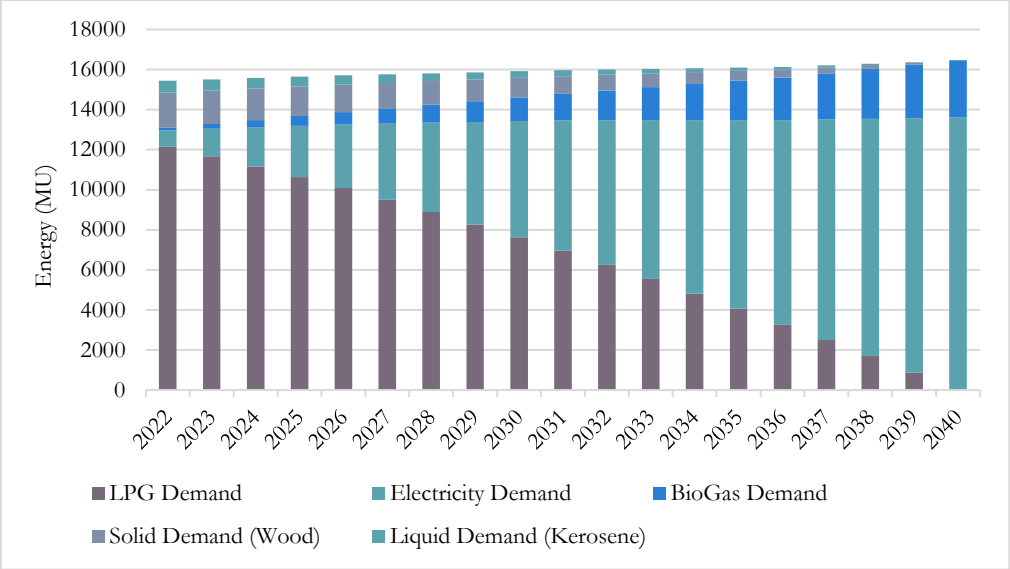


Figure 38: Cooking Energy Consumption between 2022 and 2040

Sectoral Vision

In the baseline scenario, cooking as a sector account for 1.9% of the total energy consumption of the state in 2020. This is primarily due to the widespread use of an inefficient form of fuel i.e. biomass (majorly firewood) (50%) and traditional chullahs (9%) for cooking purposes. More than 3 times more biomass is used to cook the same food as compared to LPG. While use of LPG is being promoted to reduce dependence on biomass, the uptake of CBG is also providing new avenues for the state to curb stubble burning issue. Also, use of electricity as a means of cooking is gradually being perceived by consumers as a reliable and affordable source as compared to gas based cooking, especially in urban areas.

Vision

State shall increase the use of biogas/ CBG and electric cooking in urban and rural areas and move away from emission intensive cooking fuel and inefficient cooking practices.

Action Plan

Cooking (Urban)

Objective: State shall increase penetration of gas and electricity to increase their share in the final energy requirement to 80% in urban cooking by 2030 and 100% in urban cooking sector by 2040.

Activity

A.1: State shall ensure universal access to affordable, reliable and modern cooking solutions to the entire population by 2030

A.2: State shall ensure 100% urban households have access to LPG / PNG by 2030

A.3: State shall provide requisite technical, financial and infrastructure support to increase penetration of electricity, LPG and PNG in the state

A.4: State shall promote the deployment of induction cooktops, solar cookers, solar food dryer, etc. at the community level.

Cooking (Rural)

Objective: State shall reduce the share of traditional biomass to 0% by 2040, through increased use of gas and electricity as a cooking fuel.

Activity

B.1: State shall ensure universal access to affordable, reliable and modern cooking solutions to the entire population in the state by 2040

B.2: 100% shift away from firewood, dung cakes, agriculture residue, and charcoal towards improved cook stoves by 2040

B.3: State shall provide requisite infrastructure support to increase penetration of LPG, PNG, CBG and electric cookstoves in rural areas

B.4: State shall increase awareness of rural consumers regarding benefits of using LPG / PNG, CBG and electricity over traditional biomass for cooking.

B.5: State shall promote solar energy for institutional cooking in Odisha

B.6: State shall encourage people to use renewable energy by installing biogas plants for cooking purposes

Table 34: Summary of recommendations for cooking sector

Sr. No.	Sector	Recommendation category	Recommendation	Type of Scenario	Timeline	Type of Intervention	Stakeholder
1.	**Rural**	Increase penetration of LPG	Increase the penetration of LPG in households	Aggressive	Short to Medium	Market development	RD&P, OMCs, OREDA
2.			Enable SHGs and other local outlets to become extension counters for rural distributors	Aggressive	Short to Long	Market development	RD&P, OLM
3.			Provide easier access of LPG refills to households through self-help groups (SHGs) and allow for flexible payment plans to promote the sustained use of LPG	Aggressive	Short to Medium	Financial	RD&P, OLM
4.			Creating awareness about adopting LPG stoves with improved thermal efficiency	Aggressive	Short to Long	Awareness	DST, RD&P, OREDA
5.			Undertake awareness programmes for disseminating benefits of switching from biomass to LPG as a cooking fuel	Aggressive	Short to Medium	Awareness	RD&P, OREDA
6.		Increase penetration of biogas	Promoting setting up of biogas plants under GOBARDhan Scheme through co-operative network	Aggressive; Decarbonization	Short to Medium	Financial	RD&P, OREDA
7.		Increase penetration of Electricity	Assess power distribution infrastructure development required to support use of electricity in cooking and develop implementation roadmap	Aggressive; Decarbonization	Medium to Long	Technical	GRIDCO, OREDA
8.	**Urban**	Increase penetration of Electricity as fuel	Improve the quality of electricity access	Aggressive; Decarbonization	Short to Medium	Technical	GRIDCO
9.			Improve the energy efficiency of induction cook stoves	Aggressive; Decarbonization	Medium to Long	Technical & Financial	DoP, DST, Private entities, Technical Institutions
10.			Increase penetration of electric cooking equipment by using different business models	Aggressive; Decarbonization	Short to Medium	Technical, Financial	GRIDCO, OREDA, RD&P
11.			Undertake stakeholder outreach programs through mass media channels to create awareness on benefits of using electricity for cooking	Aggressive; Decarbonization	Short to Medium	Awareness	OREDA, GRIDCO
12.	**Rural and urban**	Increase penetration of biogas	Undertake awareness programmes for disseminating benefits of switching to biogas as a cooking fuel	Aggressive; Decarbonization	Short to Medium	Awareness	RD&P
13.		Increase penetration of natural gas	Providing fiscal incentives to increase penetration of piped natural gas in urban and rural areas	Aggressive	Short to Long	Technical	RD&P, OREDA
14.		Integration of solar energy in cooking sector	Promoting solar energy for institutional cooking in Odisha	Aggressive; Decarbonization	Short to Long	Technical	RD&P, OREDA

Recommendations for Cooking Sector

1. Increase the penetration of LPG in households

There are 2 key benefits of using LPG over biomass:

a) **Health benefits.** For an average Indian household, traditional cooking using biomass emits 1.4 tonnes of CO_2 per annum and around 0.4 tonnes of CO2 per annum (Clean, Affordable and Sustainable Cooking Energy for India: Possibilities and Realities Beyond LPG 2015). This has substantial implication on health of user and according to World Health Organization sustained exposure to particulate matters and noxious gases such as carbon monoxide can lead to death (CEEW 2020).

b) **Heat content of fuel.** Most biomass sources have net calorific value (NCV) between 3500-4500 kCal/ kg and in case of wood waste and barks, it can go down to 2500 kCal/ kg. LPG on the other hand, has a NCV of nearly 11500 kCal/ kg (Business Standard 2015). Thus, the time required for cooking substantially decreases by using LPG instead of biomass.

However, the prime issue in adoption of LPG is availability and price of gas cylinder[16]. In order to reduce the use of firewood for cooking, the state can further leverage the central scheme PMUY to increase penetration of LPG. PMUY scheme offers subsidy of INR 200 per 14.2 kg cylinder for up to 12 refills per year to the beneficiaries (PIB 2023); however, with the increasing prices of LPG in the international market, such a subsidy only partially shields PMUY beneficiaries from high LPG prices.

The other issue is of availability which relates to transportation of the new cylinder from the point of sales to the households. In order to address the issue of transportation, the state government can facilitate introduction of LPG distribution centres at local co-operatives and enable self-help groups and other local outlets to become extension counters for rural distributors.

Furthermore, there are 6749 nos. of Kisan Seva Kendras (Mo Seba Kendras) in Odisha operated by Government of Odisha (Government of Odisha 2022). They could be directed to stock up feasible number of 14.5 kg and 5 kg cylinders, or several 2 kg cylinders, to facilitate better access to the rural customers. This would improve the visibility of LPG among customers who visit MSKs to purchase agricultural inputs and equipment and would improve the ease of purchase when required. It could also play a part in displacing small cylinders that are sold and refilled by informal vendors.

2. Enable self-help groups (SHGs) and other local outlets to become extension counters for rural distributors

To improve availability in villages, sub-distributorships could be allowed within safety limits and with verifiable background and infrastructural checks. The current guidelines allow the storage of up to 100 kg of gas – 6 large cylinders or 20 small (5-kg) cylinders at retail outlets (Ministry of Petroleum & Natural Gas 2013). The potential sub-distributors here could be SHGs with an existing track record of operating commercially viable businesses. Such alternative models can immensely encourage the visibility and use of LPG by the rural community.

This needs to be a three step process having components of awareness, availability coupled with affordability. Firstly, SHG members can engage with individuals in their local area to improve awareness of the negative health effects of household air pollution from the use of the traditional challah (firewood stoves), and of the safety procedures and use practices of LPG. SHG members can also build a case for sustained use, by explaining how the time saved can be used for income generation. They can reach out to households with LPG connections to discuss and understand the nature and extent of the time saved as a result of LPG use, and can connect women with appropriate income-generating possibilities that could be leveraged during the time saved.

[16] Cost of one LPG cylinder for domestic use in Bhubaneshwar was INR 1,129 of March 31, 2023. (https://www.goodreturns.in/lpg-price.html#Today%27s+LPG+Price+in+Indian+Metro+Cities+%26+State+Capitals)

LPG distributors that currently deliver LPG cylinders to a local community point, could instead deliver the cylinders to the SHG members running the sub-distributorship. The distributor can deliver cylinders—based on the sales at the SHG—once or twice in a fortnight. There could be a predetermined commission for the SHG member for stocking the cylinders, interacting with households, and collecting payments from them. This can be provided by the distributorship from the commission that it receives for each cylinder. The commission can be mutually finalized between the SHG and the distributor at the time of the contract.

Households could be given the option to make staggered payments through the SHG sub-distributorship. The SHG could accept payments on an ad hoc basis from the households. SHGs' micro savings and microcredit facilities would help to streamline cash flows for the household and overcome the lumped cost issue with LPG refills.

3. Provide easier access of LPG refills to households through self-help groups (SHGs) and allow for flexible payment plans to promote the sustained use of LPG

SHGs operating under the NRLM could be mandated to help in the procurement of LPG cylinders by enabling smaller payments through group-based lending. This model has been successfully implemented in some states in India. For instance, Jagriti, an NGO from Himachal Pradesh, employed a consumer finance approach through its women's savings and credit groups (WSCGs), to enable low-income households to use LPG and other improved cooking technologies (UNDP 2011).

Women can be encouraged purchasing LPG through one or a combination of the following:

- Using personal savings
- Using flexible payment plans in which the women pay their Group Organizer in small monthly instalments over six months or more.

Members, both within and between different groups, can help each other through loans and shared collateral in order to bring improved cooking solutions to their homes. To ensure efficient management of financial operations, the Group Organizer of each SHG could be provided training in various areas including leadership, bookkeeping, conflict management, product development, record-keeping, group management, and participatory decision-making processes.

A study by Global Alliance for Clean Cookstoves (Global Alliance for Clean Cookstoves 2013) shows that the use of LPG and upgraded cooking devices grants local women the freedom of up to six hours each day, as they are no longer required to make daily journeys to gather fuelwood. Additionally, it saves them approximately one to one-and-a-half hours of cooking time on a daily basis. Evidence has shown that women are able to engage in additional income-generating activities by freeing up time previously used in collecting firewood. . Men became more supportive of women's participation in activities outside the home, and some began to participate in household cooking because of the easier process cooking with the LPG.

This socio-economic benefit of provision of LPG for household cooking in rural areas needs to be promoted. To effectively scale up the adoption of LPG in rural areas, partnerships with women's groups should strongly be considered by the GoO. Local partnerships can leverage women's trust and expand the program's reach without reinventing the wheel. As such, the first step here would be identify district-wise most suited SHGs under NRLMs and developing promotional campaigns with them. This is to ensure that these SHGs could create awareness among the women community in rural area about clean cooking and instil best practices in them to manage group-based lending for procurement of LPG cylinders.

4. Creating awareness about adopting LPG stoves with improved thermal efficiency

The thermal efficiency of the LPG stoves used in India is about 55–57%, which is much lower than the 84% efficiency of induction stoves (Clean, Affordable and Sustainable Cooking Energy for India: Possibilities and

Realities Beyond LPG 2015). Enhancing stove efficiency will result in decreased gas consumption and enhance the cooking experience. Certain oil marketing companies (OMCs) are making efforts to introduce more efficient stoves to their new customers. IOCL, for instance, is providing its customers with stoves that have an efficiency of 68% and are certified by the Bureau of Indian Standards (BIS) (IOCL 2023). The Bureau of Energy Efficiency (BEE) also has a voluntary energy-star labelling system to rate the efficiency of domestic LPG stoves. The lowest star rating comprises efficiency between 68–72%, and the highest is above 81% (BEE 2016).

Similarly, BPCL has recently introduced LPG stove with 74% thermal efficiency which could help a family of 4 to use one less cylinder in a year. Its burner top provides optimized flame orientation, the enhanced mixing tube ensures better air-fuel mixing and help prevents heat loss. Radiant burners are an alternative to conventional burners in terms of improved efficiency (BPCL 2023). Radiant burners use a porous material to mix fuel and air and to house the flame, producing both convective and radiant heat. Studies have shown that radiant burners can provide an efficiency rate of up to 71% (Muthukumar 2011). As such, it is suggested that the Department of Housing & Urban Development and Rural Development Department in Odisha create awareness about the adoption of efficient LPG stoves which can reduce households' LPG gas use for cooking and be economically viable. Creating awareness about the Use of such thermal efficient burners / stoves which could result in reduced consumption of LPG within the state is paramount.

5. Undertake awareness programmes for disseminating benefits of switching from biomass to LPG

As discussed for above sub-activities, LPG provides substantial health benefits over biomass / firewood as a fuel. Awareness can be generated regarding the benefits of LPG over biomass by organizing stakeholder outreach programs. Rural Development and Panchayats (RD&P) Department, the anchor department for this sub-activity can mobilize the gram panchayats to spread awareness on the matter. Also, NGOs can be engaged for additional support on spreading awareness.

The communications and publicity strategy should highlight specific aspects of the technology covering energy independence and security, low recurring costs in comparison to other gas-based solutions, including household and animal waste management. Comparing it with traditional chullahs could highlight the ease of use.

6. Providing fiscal incentives to increase penetration of piped natural gas in urban and rural areas

Initiatives are being taken across the state for implementation of PNG. For instance, GAIL (India) Limited, which has been authorized to operate in Khurda and Cuttack under the city gas distribution (CGD) project, had set a target to supply PNG to the 75,000 households in the two cities by December 2022 (target still not met) and add more 20,000 connections per year from 2023 onwards (GAIL 2020). However, progress has been slow. One of the main issues is that the permission to connect the main pipeline with households is still awaited in several locations. The slow progress in laying the underground pipes has been a major stumbling block in the completion of this project. For faster penetration of piped natural gas, the downstream infrastructure in terms of distribution pipelines, city gas distribution (CGD) infrastructure, city gas stations, etc.

For CGD, accelerating the bidding of remaining districts, setting up single window clearances and improving the execution speed of network build-out could be considered by Odisha. It is also important to go beyond pipelines and look at other avenues of making natural gas available to the households for cooking. Lessons could be learnt from international experience whereby trucks are already being used to reach LNG demand centres where scale does not permit pipeline builds. Other countries have used railways. A developed East Asian country has been transporting LNG by railroad since 2000, and a North American country started doing so in 2016. These options could help Odisha to supply gas to customers who can afford LNG but do not have / are facing difficulty in receiving pipeline connectivity.

7. Promoting solar energy for institutional cooking in Odisha

Ensuring use of clean cooking technologies that offset use of traditional, polluting stoves and fuels could contribute to the achievement of several SDG goals, in particular SDG 12 (ensuring sustainable consumption and production patterns) and climate mitigation. It shall also contribute to the achievement of SDG 3: Good Health and Well Being by significantly reducing air pollution (HAP); SDG 7: Affordable and Clean Energy.

The first use case of such cooking would be for the cooking of mid-day meal (MDM) in government schools in Odisha. Lessons could be learnt from Nepal where the use of institutional cooking using solar is widespread practice in areas where the grid is unable to reach.

Case of Nepal

A case study from Nepal focuses on a School for vulnerable children aged 5–18 years which provides meals for their residential students. The solar-based institutional cookstove was used four to five times per week to cook food or boil water for drinking and saved significant costs on LPG which represented a major drain on school budgets. Prior to the installation of the solar cookstove, the school had used 7–8 cylinders of LPG per month to help prepare food that had a short cooking time, such as fried vegetables, but this fell to 5 cylinders per month afterwards till the time of the study. Sold at approximately USD 15 per cylinder, the new cookstove is capable of saving the school around USD 400 per annum as a

A variation in this could be solar cooking system of community size where temperature of 350-400 degrees C can be generally achieved. A 7m² sized solar dish can cook the food for 50 people and large sized dish (16m2) can prepare meal for more than 50–100 people. Traditional food such as chapattis, boiling or frying rice, vegetables, cereal, pulses, etc. can be easily prepared using such cooking systems. Experience has shown that due to high temperature achieved in the system, the cooking time typically reduces by 45 minutes than conventional solar cookers. A large solar cooking system was installed at Sai Baba Shridi, Ahmednagar, Maharashtra for cooking food for 20,000 people per day during 2009. The system has been generating 3,500 kg of steam daily, which has resulted in saving of 100,000 kg of cooking gas up until now. (Aggarwal 2020).

Case of Goa University

Goa University has installed concentrated solar cooking system with patented AGNi69 solar grade mirror technology at the 300-person boys hostel which is used to cook rice and lentils. The system costs around INR 50 Lakhs and boasts a lifespan of 20 years. The water gets heated when being sent to the receiver and turns to steam. The steam will be transferred to the cooking vessels directly or connect to the back-up boiler header line. The extra heat energy can be stored in the insulated storage tank for non-sunny hours

Cooking practices are driven by the community's socio- economic, cultural, environmental and food habits. The most difficult part of the transition in the initial phase is going to be shifting people's paradigms, beliefs and behaviours. Capacity building of the population with respect to the risks associated with traditional cooking stoves, in particular those related to negative health, environmental and economic impacts would be paramount.

In particular, economic factors and high cost of the technology represent major elements influencing improved cook stove (ICS) adoption since many of the households do not often indulge in cash economy. For the large scale adoption of institutional solar cooking in the state, incentives would be required by the state government to ensure their financial attractiveness. Incentive structure could be kept similar to the Jawaharlal Nehru National Solar Mission (JNNSM) whereby 30% advance financial assistance in the form of capital subsidy was being provided for procurement and installation of decentralised solar cookers. Here 70% could be the installer's equity.

8. Promoting setting up of biogas plants under GOBARDhan Scheme through co-operative network

Biogas can provide an alternative to the forms of energy available for cooking. In the Union Budget 2023, it was announced that, across the country, in the 'Green Growth' segment, 500 new Waste to Wealth plants will be established under the GOBARdhan scheme for promoting the circular economy. These will include 200 compressed biogas (CBG) plants, including 75 plants in urban and 300 community or cluster-based plants at a total investment of INR 10,000 crores (PIB 2023). Taking a step ahead, the Government of Odisha can leverage this scheme to set up biogas plants for cooking purposes under the GOBARdhan scheme through co-operative mechanism. Further, the National Bioenergy Programme (NBP) also promotes development of family type biogas plants to meet cooking needs of households (Ministry of New and Renewable Energy 2022).

While these central level schemes are promoting biogas use, an alternative implementation mechanism could be using the cooperative network to set up biogas plants for cooking purposes in the state. There are multiple examples of co-operative setting and running biogas plants in India. A similar model can be replicated in the case of Odisha with the village co-operatives taking up the initiative of setting up and maintaining the biogas plants.

In such a case, the initial funds for setting up the plant can be provided by the State Government in the form of interest-free loan. The co-operative can recover the costs by charging usage fee on the biogas supplied. The co-operative can also sell the bio-digested slurry as manure, thereby providing for additional income. A part of the amount generated can be allocated to cover for operational costs.

Apart from co-operatives installing and operating biogas plants, penetration of biogas can be pursued at the household level. A model can be adopted for Odisha wherein, grants or subsidy can be provided by the state Government. Else a loan can provided by the co-operatives at less-than-market rates. The loan could have flexible repayment schedules to ensure participation from households in this initiative.

9. Undertake awareness programmes for disseminating benefits of switching to biogas as a cooking fuel

To improve the uptake of biogas, it is pertinent to establish demand-side indicators for improved monitoring and evaluation of existing biogas schemes and their adoption and use at the community level within the state. The biogas sub-scheme under the National Bioenergy Programme and the CFA available as part of the scheme also needs to be promoted in the state. The involvement of local stakeholders (end-users and opinion leaders) through capacity building, monitoring, and regulating and training could encourage a more 'demand-driven' approach and ultimately, encourage the adoption of biogas for cooking in the state.

Biogas could also be promoted by linking it with income-generating activities such as food preservation, drying, and other such household-level food processing, if their economics works out better than other clean cooking fuels. Hence, focused awareness campaigns must include a technology demonstration to visually differentiate modern biogas plants from the kind that were installed previously.

10. Assess power distribution infrastructure development required to support use of electricity in cooking and develop implementation roadmap

While penetration of LPG / PNG achieved in Odisha will successfully lead to a switch from relatively inefficient and polluting biomass, the ultimate aim would be to increase penetration of electric cooking equipment. This provides an immense opportunity for utilities to increase their revenue base.

However, tapping this revenue base would require strengthening the power distribution system as well as providing reliable and quality power supply. Undertaking this task would require technical studies to be conducted in the medium to long term to establish the requirement for distribution network in the designated area.

11. Improve the quality of electricity access

Through rural electrification schemes such as Deen Dayal Upadhyaya Gram Jyoti Yojana (DDUGJY) and SAUBHAGYA, state has focused on the electrification of villages and households, but reliability and quality of supply still remains a significant challenge. Without assured quality (consistency in voltage), reliability (occurrence

of black-outs), and sustained duration of electricity supply, households are unlikely to invest in induction cook stoves and other such electric cooking devices, given that they currently have the flexibility of cooking at any time of the day with the traditional chullahs and LPG. The government's ambition to provide all households with 3-phase power 24x7 by 2022 (PTI 2015) will be instrumental in unlocking the potential of electricity-based cooking in rural areas.

Due to the shift towards electric cooking, energy in the cooking sector in the state is expected to grow from 15.4 TWh to 16.5 TWh between 2021 and 2040 with one of the major fuels being electricity consuming 5.1 TWh under decarbonization and aggressive scenarios.

12. Improve the energy efficiency of induction cook stoves

On average, with three hours of cooking in a day, a household's monthly expenditure on electric cooking energy will be between INR 630 – INR 945 which is chEPer that than of expenditure on LPG. A simple cost-benefit analysis is presented below:

Table 35: Cost comparison of LPG vs electric cooking

Parameters	Values
Cost of 1 LPG cylinder	INR 1,120
Number of cylinders used in a month (households of 4 members)	2
Total amount spent on LPG cylinders in a month	**INR 2,240**
Typical wattage of electric cooktops	1800 W – 2100 W
Assumed hours of cooking in a day	2 hours
Monthly household expenditure on electric cooking energy	**INR 540 – INR 630**

Assumptions:

1. Assuming 2 hours of cook time in a day[17], the spending on electric cooktops is lower than the spending on acquiring LPG cylinders by a typical urban household with 4 members. Electric cooktops prove to be more energy efficient.
2. Average per unit cost of electricity assumed at INR 5 / unit for the consumer (Source: Odisha tariff order)
3. 0% interest rate assumed for EMI

However, if households are to rely entirely on electricity-based cooking, it is important to improve the energy efficiency of induction cook stoves and other commonly used electric devices. This would help households minimize their energy consumption and lower their recurring expenditure on electricity. A few companies have set up government approved R&D centres to improve the efficiency of induction cook stoves. Although oil marketing companies and ONGC have begun start-up funds to support the development of user-friendly electric cooking appliances (IANS 2017), entrepreneurs in the sector still need more direction to innovate affordable energy-efficient appliances for the rural segment.

13. Increase penetration of electric cooking equipment by using different business models

In case of urban, semi-urban and other rural areas where uninterrupted power supply is available, cooking from electrical sources can be pursued to reduce dependence on fossil fuel. Public awareness programs are required for increase uptake of electric cooking and these programmes should exhibit benefits of electric cook stoves including ease of using them.

In addition, identifying workable business models is also paramount to enhance the penetration of e-cook stoves across the State. One way for GoO could be to use the aggregation model to bring down the cost of e-cook

[17] https://www.thequint.com/news/india/indians-spend-the-most-time-in-cooking-study

stoves. The State can identify an anchor institute, such as EESL, which can help in aggregating demand for e-cookstoves across Odisha and aid in providing economies of scale to manufacturers through regular bulk procurement. This could also help the manufacturers of e-cook stoves to reduce the cost of such solutions not just under this arrangement but eventually for the retail segment.

Another option could be that the DISCOMS provide a one-time discount in the electricity bill to those consumers who will provide the invoice for acquisition of an induction cook stove/electric cooker. This could be in the form of a discount on SGST. Net subsidy calculation based on 50% discount in SGST is provided below:

Table 36: Details of mechanism to increase penetration of Electric Cooking in urban areas aggressive scenario

Timeline	Target Penetration (%)	Target no. of Cook stoves (lakhs)	Net Cost (Rs. Crore)	SGST (INR Crores)	Net Subsidy (INR Crores)
Short	8%	6.51	497.45	24.87	12.44
Medium	15%	13.93	1063.38	53.16	26.58
Long	30%	33.75	2575.24	128.76	64.38

Assumptions:

i. Electric induction (double) cook stoves cost is INR 7630 (CEEW 2020)
ii. No. of urban households taken from Odisha energy model (Odisha energy modelling, 2023)
iii. Penetration level in 2022 is 2.1% of total no. of urban households (CEEW 2020)

Table 37: Details of mechanism to increase penetration of Electric Cooking in urban areas in decarbonization scenario

Timeline	Target Penetration (%)	Target no. of Cook stoves (lakhs)	Net Cost (INR Crore)	SGST (INR Crores)	Net Subsidy (INR Crores)
Short	39%	31.9	2434.22	121.71	60.85
Medium	50%	45.48	3470.56	173.52	86.76
Long	80%	90	6867.32	343.36	171.68

Assumptions:

i. Electric induction (double) cook stoves cost is INR 7630 (CEEW 2020)
ii. No. of urban households taken from Odisha energy model (Odisha energy modelling, 2023)
iii. Penetration level in 2020 is 3% of total no. of urban households (CEEW 2020)

14. Undertake stakeholder outreach programs through mass media channels to create awareness on benefits of using energy-efficient appliances for cooking

Electricity as a means of cooking is considerably efficient than gas and its efficiency increases further if it is used for direct induction cooking. Under test conditions, the efficiency for each type of cooking is as follows (US DOE 2018):

Table 38: Efficiency for various types of Cooking

Type of technology	Gas (old cook stoves)	Electric	Induction
Thermal Efficiency	40%	74%	84%

In addition to improving households' understanding of how electricity can improve cooking, there is also a need to make them aware of alternative energy-efficient appliances and practices. This will help in the provision of quality electricity supply and in reducing household expenditure on electricity. They will also need to be made aware of the importance of factoring in energy-efficiency ratings when making decisions around the purchase of electric consumer durables for cooking. DISCOMS can also rope in and undertake awareness building programs both in online and offline methods targeting urban consumers and spreading awareness on the cost benefit of using induction cooking over LPG or other modes of cooking.

6.6. Building Sector

Overview of Sector

For the purpose of the EP study, building types have been defined in line with the DISCOM definitions – residential, institutional (health, education, government buildings) and commercial buildings, which correspond to domestic and commercial consumer categories of distribution companies, both in rural and urban areas respectively. The treatment for residential sector excludes energy required for cooking.

Energy consumption in buildings is due to usage of lighting, household appliances and commercial heating and primary source of energy is in the form of electricity with diesel being the other source of energy in this sector. Diesel generating (DG) sets are used as an alternative to electricity in case of power outage. More so, the detrimental environmental effect of diesel and other fossil fuels on the ambient air quality, coupled with rising fuel prices will further lead to reduction in consumption of diesel for household consumption.

Within the building sector (including government buildings):

- Domestic sector forms the bulk consumer and has been growing consistently. The domestic sector accounted for 37% and commercial sector with 12% of the total power consumption in the state in 2020.
- The commercial sector constitutes government & private establishments, hospitals, hotels, restaurants, educational institutions, malls etc.
- Air conditioners and refrigeration form the bulk of the electricity consumption in the sector followed by lights and ceiling fans.
- Since the state has achieved 100% household electrification in 2018, it is expected that share of rural consumption will grow further.

Energy Consumption of Sector

In the building sector, residential and commercial energy consumption steadily increases, and the proportion of consumption remains steady between 2022 and 2040. The building sector energy consumption is growing in the state with an estimated CAGR of 6.05% from 10.89 TWh to 31.32 TWh between 2022 and 2040 under the baseline scenario. The share of residential is 79% in 2022 which remains more or less constant in 2040 in the BAU scenario. Under BAU scenario, change in the final energy demand in residential and commercial building sector is shown below:

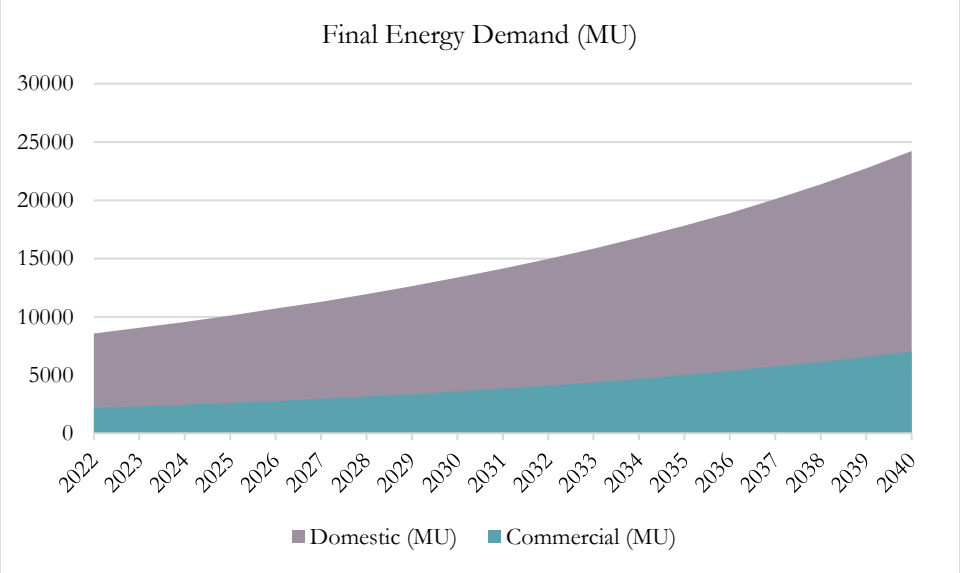


Figure 39: Final energy demand in Residential and Commercial buildings sector (MU)

Existing initiatives undertaken in the state

There are multiple initiatives which are being undertaken in the energy sphere for building sector in the state as given below:

1. Energy Conservation Building Code (ECBC) in Commercial buildings sector

The Government of Odisha has notified the ECBC code in October 2022 under the Energy Conservation Act-2001 for its mandatory use to bring energy efficiency and conservation in buildings or building complexes having connected load ≥100 kW or contract demand of ≥120 kVA or having conditioned area of ≥ 1000 m^2 (Government of Odisha 2022).

It is pertinent to mention here that BEE, Ministry of Power (MoP), Government of India (GOI) launched the updated version "ECBC (2017)" on 19.06.2017 and BEE has also notified "ECBC Rules (2018)" which describes the procedure for implementation of ECBC in the states. Further, a renewed effort has been undertaken for notifying ECBC Rules (2022) in the State of Odisha.

Odisha SDA completed the EE streetlighting project at Mukhiguda and Khatiguda colonies of Upper Indravati Hydro-electric project. Further, the State has completed implementation of EE measures involving retrofitting of energy efficient appliances / equipment in 44 Nos. Govt. schools (Bureau of Energy Efficiency 2022).

2. Eco-Niwas Samhita (ENS) in residential buildings sector

BEE, Ministry of Power, Government of India have jointly launched ECBC for Residential Buildings (ECBC-R) named as Eco-Niwas Samhita (ENS) in December 2018. The code is applicable to all residential buildings and residential parts of 'Mixed land-use building projects', both built on a plot area of ≥500 m^2 (BEE 2018). Odisha has incorporated energy efficiency norms in public procurement guidelines for lighting and appliances. The State has also started making some progress in the adoption of ECO Niwas Samhita 2018 in residential buildings.

3. Net-Zero Energy Buildings (NZEB)

In the last few years, several buildings in India have become net-zero energy buildings by offsetting their total annual energy requirement with renewable energy and by increasing their energy efficiency. The Indian Green Building Council (IGBC) started voluntary ratings of net-zero buildings in 2018, where energy-efficient building design and climate-responsive designs were also given weightage, besides the use of renewables. GRIDCO is planning to construct a zero energy building in Odisha. The building shall invite direct natural sunlight and screen radiation. It would have photovoltaic glass panels and geothermal cooling systems at strategic places along with its indigenous solar generating systems so that is sustained itself with own energy (Mongabay 2023). Further, Odisha has 37 Green Rating Integrated Habitat Assessment (GRHA)[18] buildings (Bureau of Energy Efficiency 2022).

4. Odisha State Energy Conservation Award

The Odisha State Energy Conservation Award (OSECA), launched in 2015, is expected to promote a state level recognition to the selected entities that have made systematic and continued attempts for efficient utilization and conservation of energy in previous years. The scheme envisions a multiplier effect that will help other enterprises and stakeholders working in the area of energy conservation in the State to emulate the success stories of these

[18] GRIHA is a rating tool which evaluates the environmental performance of a building, based on quantitative and qualitative criteria, thereby providing a definitive standard for green buildings and habitat. GRIHA measures a building's environmental performance on a scale of 1–5 stars. Major areas considered while evaluation of the building under GRIHA are four main categories – energy efficiency, Renewable energy, Water resources, Waste management, which is further sub divided in 31 categories such as site planning, construction management, occupant comfort and wellbeing, sustainable, and innovation.

award winning units (Energy Department, Government of Odisha 2022). The OSECA has been planned to achieve the following major objectives:

- To create awareness among the commercial buildings, hospitals, educational institutions, hotels, MSMEs, IT Industries, Power Plants (CPPs and IPPs), grid interactive domestic consumers for energy conservation on significance of energy conservation & energy efficiency and best practices.
- To promote the culture of energy conservation amongst various stakeholders.
- To recognise the effort of different entities and other stakeholders in conserving energy by way of giving them awards and recognitions / certificates of merits and to subsequently propagate the best practices for large scale replication by different sectors in the state.

5. Notifications/ Demo projects

Odisha has issued notification (Energy Department, Governmnet of Odisha 2007) for mandatory use of CFL, energy efficient metal halide fittings and lamps and energy efficient Air Conditioners in all Government sector/Government Aided Sector/ Board and Corporation/ Autonomous Bodies. Further, the State has mandated the use of BIS marked Motor pump sets, Power capacitor, Foot / Reflex valves in Agriculture Sector. All the new buildings to be constructed in Government / Government aided sector are also mandated to incorporate energy efficient buildings design concepts' including Renewable Energy Technologies. Lastly, the use of use of BIS marked solar water heating systems has been mandated in the following categories of building:

i. Industries where hot water is required for processing.
ii. Hospitals and Nursing homes including Government Hospitals.
iii. Hotels, Motels and Banquet halls.
iv. Jail Barracks, Canteens.
v. Housing Complexes set up by Group Housing Societies / Urban Development Authority
vi. All residential buildings, built on a plot of size 500 square yards and above falling within the limits of municipal committees! corporations and Orissa Urban Planning and Development Authority Sectors.
vii. All Government buildings, Residential Schools, Educational Colleges, Hostels, Technical! Vocational Education Institutes, District Institutes of Education and Training, Tourism Complexes and Universities, etc.

As per BEE report on "Impact of Energy Efficiency Measures for the year 2020-21", Odisha had one of the highest distributions of the LED bulbs under the UJALA programme (including distribution of LED bulbs, LED lights and energy efficient fans) (Bureau of Energy Efficiency 2022). Further, the total energy (toe/year) during FY 18-19 in Odisha under BEE-WB-GEF Programme has been 56 toes / year (Bureau of Energy Efficiency 2021).

6. Smart Cities Mission

The state has shown a strong commitment towards smart city development wherein the work in 2 smart cities namely, Bhubaneswar and Rourkela is going on at a considerable pace. The Bhubaneswar Smart City has tendered out 28 projects worth INR 3,538.94 crore; out of which work orders have been issued in 25 projects worth INR 2,330.62 crore. Out of tendered projects, 16 projects worth INR 873.56 crore have been completed until December 2021. The State Government has decided to make rooftop solar panels mandatory for new building plan approvals in Bhubaneswar, as part of the Smart City Mission (Times of India 2021).

7. Unnat Jyoti by Affordable LEDs for all (UJALA)

UJALA, launched in 2015, is a Central Government scheme which aims to increase uptake of energy efficient appliances by households. It started with the distribution of the LED bulbs and then expanded to LED tube lights and energy efficient fans. As per UJALA scheme, the current status of the programme in the Odisha is given in the table below (Bureau of Energy Efficiency 2022):

Table 39: Details of UJALA scheme in Odisha

Appliance	No. of appliances distributed (millions) FY 17-21	Annual Energy Savings (MU)
LED Bulb	45.4	5,802.4

Description of Aggressive Scenario (Scenario – 3)

The overall final energy demand for commercial and residential building in the aggressive scenario is shown in figure below. For detailed assumptions, please refer to section 4.1 of the report. It is observed that growth rate of energy demand in residential sector is expected to increase at 5.04% while commercial sector's energy demand is expected to increase at a rate of 5.21% between 2022 and 2040 respectively.

The figure below shows the energy consumption mix in commercial and residential building sector between 2022 and 2040 under aggressive scenario in Odisha

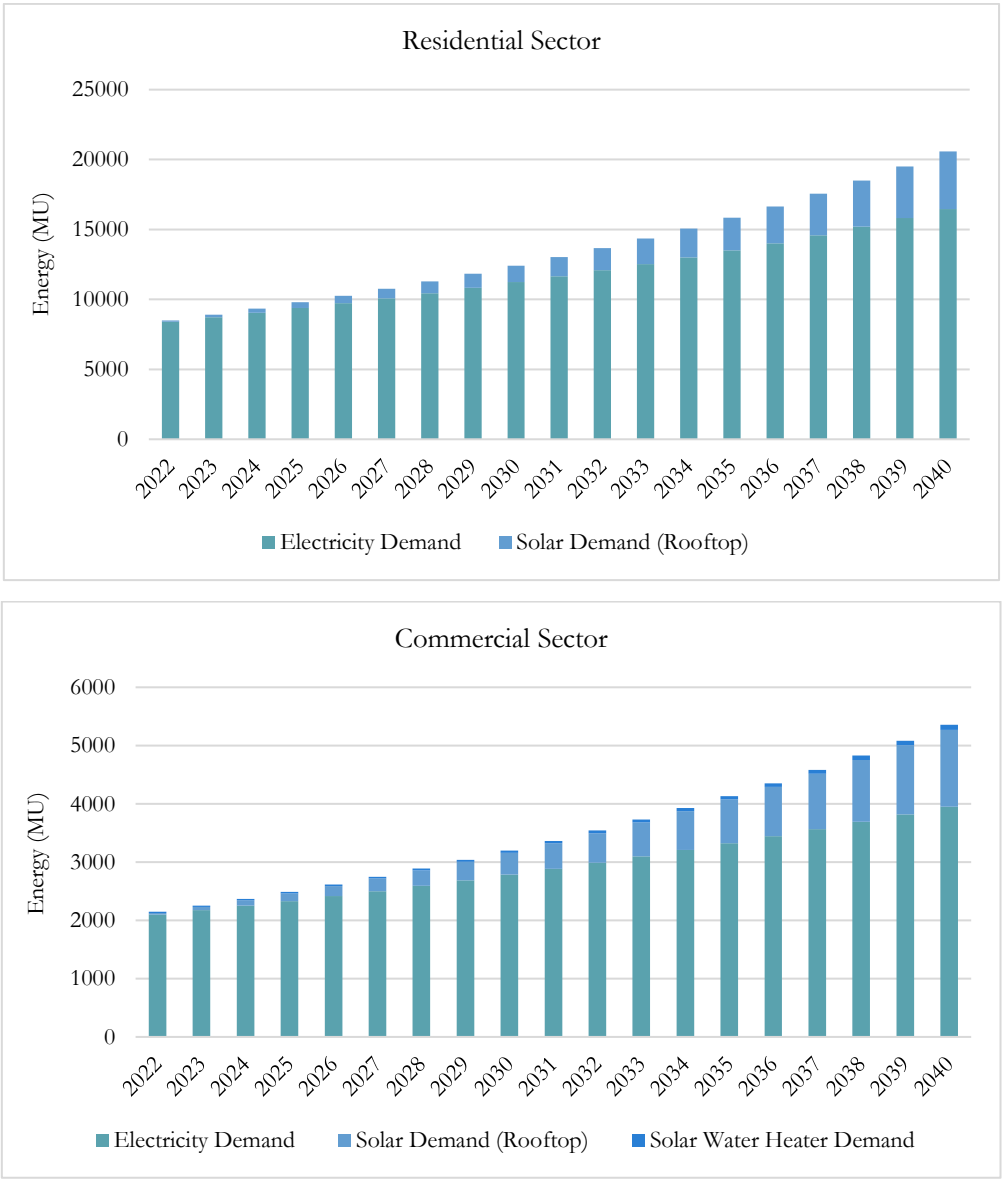


Figure 40: Energy demand for buildings sector in Odisha under aggressive scenario

In the fuel mix of the final energy of residential sector, it is observed that electricity demand is expected to increase from 8.41 TWh in 2022 to 16.47 TWh by 2040. Decentralised solar as a fuel has proportionate share in the total fuel mix which stands at 0.089 TWh in 2022 and expected to reach 4.12 TWh by 2040 due to inter fuel switching.

On the other hand, commercial sector's electricity energy demand is expected to increase from 2.1 TWh to 3.95 TWh in the state between 2022 and 2040. Similarly, final energy demand for commercial hot water use (solar water heater) is expected to steadily increase from 0.02 TWh in 2022 to 0.087 TWh by 2040.

In addition, it is to be noted that the sector also deals with the energy consumption across the cold storage facilities. The energy demand from cold storage in LC-3 scenario is increasing from 0.010 TWh to 0.017 TWh between 2022 and 2040.

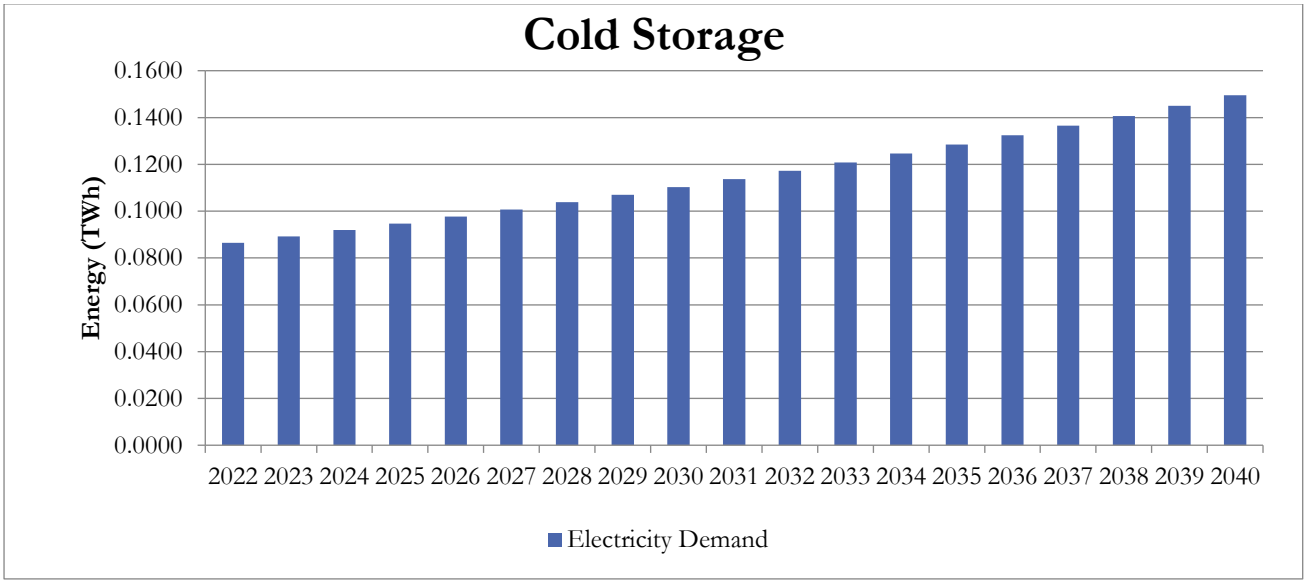
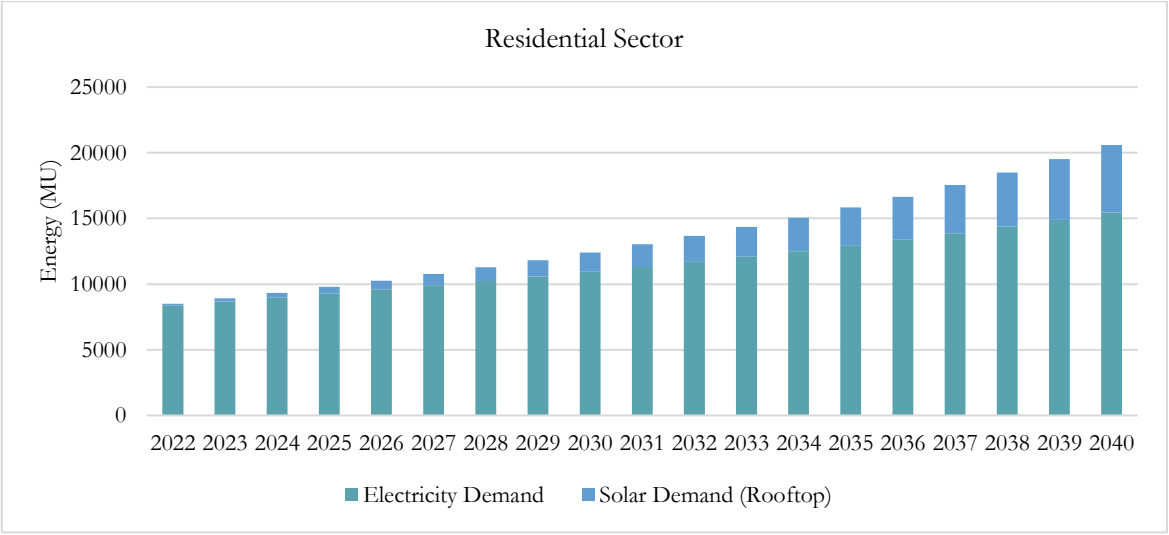


Figure 41: Final Energy demand in Cold storage (TWh)

Description of Decarbonization Scenario (Scenario – 4)

The building sector energy consumption is growing in the state with an estimated CAGR of 5.07% between 2022 and 2040 from 10.64 TWh in 2022 to 25.94 TWh in 2040. Electricity is the major source of energy for this sector and being used in two different manners, namely, electricity use for lighting, HVAC, lift and other uses and energy use for providing hot water for different purposes (hospitals, hotels use). For detailed assumptions, please refer to section 4.1 of the report.

The figure below shows the energy consumption mix in commercial and residential building sector between 2022 and 2040 under decarbonisation scenario in Odisha



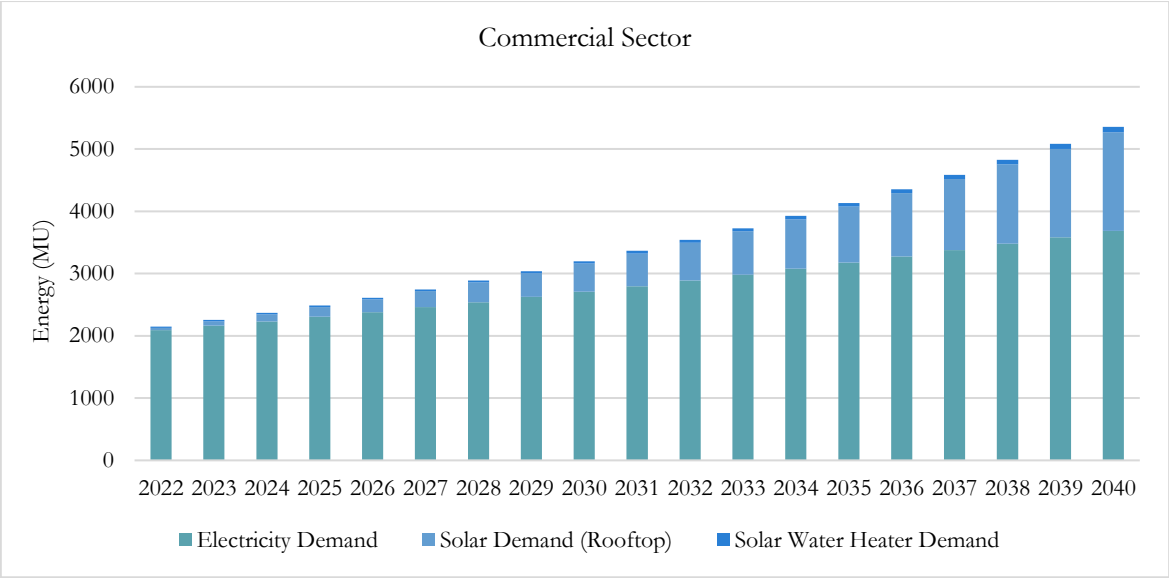


Figure 42: Energy demand for buildings sector in Odisha in decarbonisation scenario

In addition, it is to be noted that the sector also deals with the energy consumption across the cold storage facilities. The energy demand from cold storage in LC-4 scenario is increasing from 0.010 TWh to 0.017 TWh between 2022 and 2040.

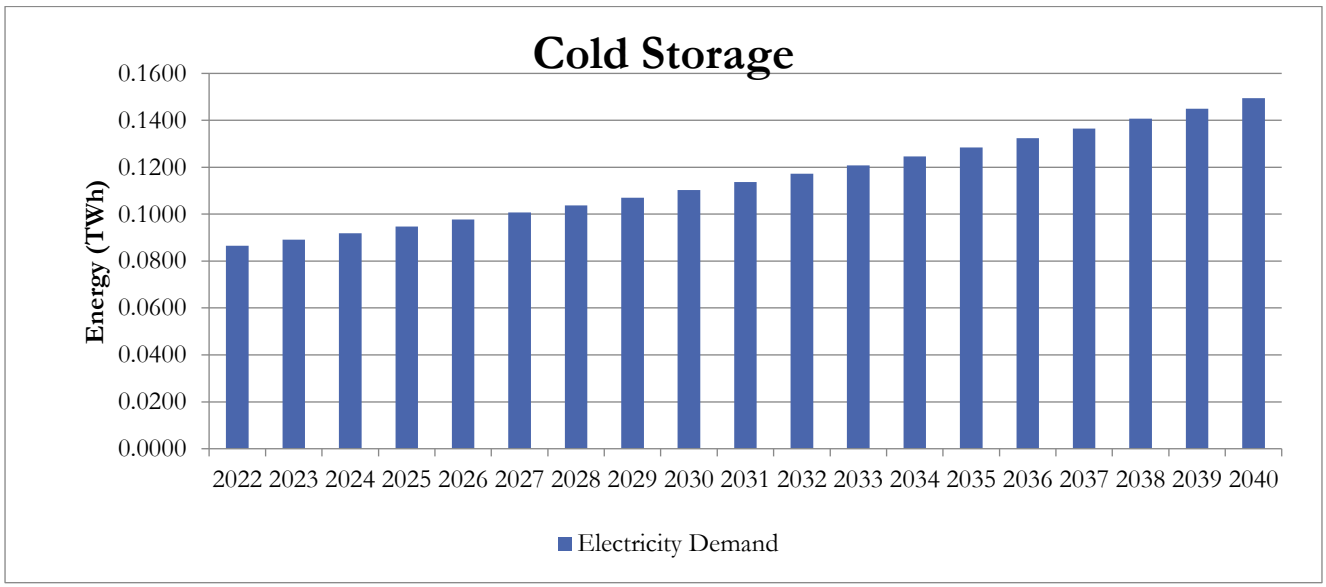


Figure 43: Energy demand for cold storage in Odisha

Since the value is small, the model is rounding off the number to present it as zero. As can be seen in the graph, the final energy demand in the cold storage sector is growing from 0.011 TWh in 2022 to 0.017 TWh in 2040.

Overall, the estimated energy demand in the building sector comprises of grid and off-grid electricity consumption in the residential and commercial buildings. The sector also comprises of solar thermal energy requirement which is primarily used for hot water supply for building typologies such as condominiums, hospitals, and hotels. Finally, the sector also includes energy demand for the commercial cold storage operations.

The decarbonize scenario indicates that the electricity consumption for the residential buildings will grow at a CAGR of 3.78% between 2022 and 2040, increasing from 8.41 TWh to 16.4 TWh and for commercial sector, it will increase at a CAGR of 3.5% respectively between 2022 and 2040, increasing from 2.1 TWh to 3.9 TWh. The detailed assumptions around RE and EE are provided in Section 4.1 of this report.

Sectoral Vision

Residential and commercial sector, combined, accounts for ~50% of the total electricity consumption in the state in FY20. Penetration of ECBC compliant buildings is low since updated code. Uptake of energy efficient appliances and solar water heating is voluntary and there is limited awareness of their benefits among consumers.

Departments of Tourism, School & Mass Education and Health & Family Welfare have approved the vision.

Vision

State will achieve improvement in energy performance of residential (15%) and commercial buildings (25%) through focus on implementation of ECBC and increased use of renewables including solar water heaters.

Action Plan

Residential Sector

a) **Objective:** State shall increase the penetration and ownership of BEE star labelled energy efficient appliances, solar rooftop and solar water heaters in residential sector.

Activity:

A.1: State shall provide financial incentives to retail consumers for increasing uptake of BEE star labelled energy efficient household applications and solar water heaters.

A.2: State shall conduct feasibility studies, pilot projects and adopt technologies that include demand side management (DSM) and demand response (DR) measures.

A.3: State shall explore innovative RE solutions for building design such as passive solar building complex, building integrated solar PV (BIPV), solar glass panels, solar parking sheds, solar rooftop, etc. for all new residential building complexes.

A.4: DISCOMs in the State shall maximise solar rooftop penetration in households for electricity and water heating requirements.

A.5: State shall ensure 100% of street lighting to be LED or solar lights by 2030.

Objective: State shall set the targets for mandatory implementation of energy conservation building code (ECBC) in residential buildings.

Activity:

B.1: State shall proactively implement ECBC for residential sector and provide adequate institutional, regulatory and infrastructural support to ensure stringent implementation.

B.2: State shall generate awareness and conduct capacity building programmes among relevant stakeholders and at various levels including skilled manpower for enabling green construction in residential buildings.

B.3: State shall explore EE measures for building design such as EE building envelope, double pane windows, LED occupancy / vacancy sensors, decentralized heat pumping systems, etc. for residential buildings.

Commercial Sector

Objective: State shall increase the penetration and ownership of BEE star labelled energy efficient appliances, solar rooftop and solar water heaters in commercial sector.

Activity:

A.1: State shall create mechanism/ plan and implement projects to increase the uptake of BEE star labelled energy efficient household applications and existing electric water heater arrangement with solar water heaters.

A.2: State shall undertake outreach programs for relevant stakeholders to increase awareness of benefits of energy efficient appliances and solar water heaters.

A.3: State shall promote grid connected rooftop solar PV projects to be set up on public buildings, healthcare centres / hospitals and other commercial buildings

A.4: State shall explore innovative RE solutions for building design such as passive solar building complex, building integrated solar PV (BIPV), solar glass panels, solar parking sheds, solar rooftop, etc.

Objective: State shall set the targets for mandatory compliance of energy conservation building code (ECBC) in commercial buildings.

Activity:

B.1: The benchmarking exercise/ studies shall be taken up by the state for further revision over time in Odisha ECBC code based upon the building topologies.

B.2: State shall proactively implement robust institutional and regulatory framework to ensure implementation of ECBC code in commercial buildings along with adequate market capacity.

B.3: State shall increase awareness of relevant stakeholders on the benefits of adopting ECBC as well as prevalent regulatory requirements for compliance to ECBC.

B.4: State shall incorporate the best practices from the three rating systems into a single comprehensive platform to create awareness among the stakeholders that addresses every aspect of energy efficiency in buildings

B.5: State shall explore EE measures for building design such as EE building envelope, double pane windows, LED occupancy / vacancy sensors, decentralized heat pumping systems, etc. for commercial buildings

Views of Departments on vision

Tourism

- For properties owned by Department, the shift to renewable energy shall be evaluated on case-to-case basis based on feasibility
- Department shall ensure 100% compliance with the ECBC code
- Department is installing solar powered lights at tourist spots and also planning to set up EV charging stations at major tourist destinations

Health

- Department plans to take up solarization of 32 District Hospitals and 7 Medical Colleges in the first phase. Other facilities shall be taken up in phased manner depending on feasibility.

School & Mass Education

The following table provides the list of identified strategies in the form of action plan to improve energy efficiency in building sector, including sub-activity, timeline, type of intervention and responsible stakeholders in the state of Odisha:

Table 40: Summary of action plans for building sector

Sr. No.	Sector	Recommendation category	Recommendation	Type of Scenario	Timeline	Type of Intervention	Stakeholder
1.	**Commercial Buildings**	Implementation of ECBC code	Model regulations for Odisha ECBC Rules 2022 for its incorporation and implementation roadmap along with requisite supporting infrastructure in the state by various stakeholder departments	Aggressive; Decarbonization	Short to Medium	Regulatory/ Institutional	SDA, OUHM, Dept. of Local Govt.
2.		Market development to facilitate the implementation of ECBC code	Undertake awareness programs on building energy conservation and efficiency as well as building labelling systems	Aggressive; Decarbonization	Short to Medium	Awareness generation	SDA, GRIDCO
3.			Provide institutional and regulatory support to businesses providing ECBC compliant building material and building energy management system	Aggressive; Decarbonization	Short to Medium	Policy & regulatory, institutional	SDA, OUHM, Dept. of Local Govt.
4.			Creation of centres of excellence to promote green buildings and strengthening R&D activities	Aggressive; Decarbonization	Medium to Long	Market Development, Technical	SDA, Technical institutions/ centres
5.		Increase the uptake of renewable energy in commercial buildings	Encouraging development of building integrated PV	Aggressive; Decarbonization	Short to Long	Technical, Market Development	GRIDCO, Dept. of Local Govt.
6.			Exploring the possibility of integrating solar glass panels in new commercial buildings	Aggressive; Decarbonization	Short to Long	Technical, Market Development	GRIDCO, Dept. of Local Govt.
7.			Integrating solar rooftop in community health centres and primary health centres in rural areas in Odisha	Aggressive; Decarbonization	Short to Long	Technical	GRIDCO, Odisha Health Department

8.			Encouraging development of sustainable hospitals in urban areas	Aggressive; Decarbonization	Short to Long	Technical, Awareness generation	GRIDCO, Odisha Health Department
9.			Deployment of innovative renewable energy solutions for the tourism sector	Aggressive; Decarbonization	Short to Long	Technical, Market Development, Institutional	GRIDCO, Department of tourism
10.			Facilitating rapid developments in innovative solid and liquid waste management to manage waste resulting from tourist activities	Aggressive; Decarbonization	Short to Long	Technical, Market Development	GRIDCO, Department of tourism, Forest, Environment and Climate Change Department
11.			Promote and ensure the use of renewable energy for all of the sports infrastructure across rural and urban areas	Aggressive; Decarbonization	Short to Long	Technical, Awareness generation	Sports and Youth Services Department, GRDICO
12.			Develop and encourage sustainable transportation options for sports events and activities	Aggressive; Decarbonization	Short to Long	Technical, Awareness generation	Sports and Youth Services Department, State Transport Authority
13.			Renovate and reconstruct sports facilities in Odisha with a focus on green building principles	Aggressive; Decarbonization	Medium to Long	Technical, Policy & Regulatory	SDA, Sports and Youth Services Department
14.		Increase the uptake of energy efficiency and energy conservation measures/ activities	Continue to undertake replacement of inefficient electrical equipment/ appliances with BEE star labelled energy efficient appliances and solar water heaters	Aggressive; Decarbonization	Medium to Long	Technical	SDA
15.			Undertake replacement of inefficient electrical equipment/ appliances with BEE	Aggressive; Decarbonization	Short to Long	Technical	OREDA, SDA

			star labelled energy efficient appliances and solar water heaters in buildings				
16.			Develop and undertake pilot projects for demand side management (DSM) and demand response (DR) programs	Aggressive; Decarbonization	Medium to Long	Technical, Institutional	GRIDCO
17.	**Residential Buildings**	Increase the uptake of energy efficiency and energy conservation measures	Develop awareness of retail buyers on the benefits of energy efficiency for buildings and building labelling program	Aggressive; Decarbonization	Short to Medium	Awareness generation	SDA, OUHM, Dept. of Local Govt.
18.							
19.			Develop implementation roadmap for demand side management (DSM) and demand response (DR) programs	Decarbonization	Medium to Long	Technical, Institutional	GRIDCO
20.			Undertake replacement of inefficient electrical equipment/ appliances with BEE star labelled energy efficient appliances and solar water heaters in buildings	Aggressive; Decarbonization	Short to Long	Technical	OREDA, SDA
21.			Exploring the possibility of integrating solar glass panels in new residential buildings	Aggressive; Decarbonization	Short to Long	Technical	GRIDCO, Dept. of Local Govt.
22.			Develop implementation roadmap of ECBC code for residential buildings	Decarbonization	Short to Long	Institutional	SDA, OUHM, Dept. of Local Govt.

Recommendations for buildings sector

1. Model regulations for Odisha ECBC Rules 2022 for its incorporation and implementation roadmap along with requisite supporting infrastructure in the state by various stakeholder departments

The Government of Odisha (Energy Department) has notified the latest draft of the ECBC code in the state in 2022 to be mandatory in buildings or building complexes having connected load ≥100 kW or contract demand of ≥120 kVA or having conditioned area of ≥ 1000 m^2. Since the state is revising the ECBC code and has implemented numerous amendments since its launch in 2020, the Hyderabad model can be used to develop a regulation more tailored to Odisha's regional considerations (MERCOM 2018) whereby the ECBC compliance has been incorporated in an online building approval system (DPMS) of urban local bodies and 38 ECBC third party assessors are empanelled with the Telangana State Renewable Energy Development Corporation and GHMC. Drawing learnings from this model, on the impact of various initiatives like online building approval system, empanelment of third party assessors, appropriate changes can be made in consultation with sectoral experts and the ECBC Implementation Cell of OREDA.

Further, in order to facilitate a seamless implementation of the ECBC Rules, an implementation roadmap needs to be developed, highlighting the roles and responsibilities of various key stakeholders. For instance, real estate developers shall be roped in to prepare designs in line with Municipal by-laws in consultation with OREDA, architects and municipal electrical and plumbing consultants. A third party assessor comprising of Buildings Certified Energy Auditors under BEE regulations, 2021 shall be responsible for assessing the building design submitted by the real estate developer and provide ECBC compliance certificate. Also, a building approval committee comprising the officials from Bhubaneswar Development Authority (BDA), Department of Local Government, and Municipal Corporation along with independent building certified energy auditors shall review the submitted building plans and ensure the compliance with ECBC requirements.

Therefore, state shall develop sufficient number of third party assessors and experts to review the building plans and they should be empanelled with BDA/ OREDA. Additionally, an ECBC cell shall be constituted in key stakeholder departments with a wide exposure of ECBC code for the effective implementation and fast-tracking of ECBC approval process.

2. Undertake awareness programs on building energy conservation and efficiency as well as building labelling systems

Adopting ECBC code at the local level is the first and the foremost step in its successful implementation. Going ahead, the next step is to motivate the key stakeholders i.e., citizens, project developers, commercial property owners and architects and make them well versed to the code and help them understand the financial, environmental and health benefits of adopting the code. End-users' buy-in is crucial for successful implementation of ECBC code and realizing its objectives.

The state shall conduct regular meetings/ awareness/ capacity building programs for key stakeholder departments and build training materials and short/ conceptual factsheets and flyers on basics, requirements and brief overview of ECBC code. For wider reachability, state shall also conduct ECBC benefit analysis to show the energy saving potential and economic savings and its comparison among various building energy saving measures. The state shall also focus on developing pilot case studies on ECBC for building developers, architects, engineers and building industry professions and city level studies that can help the departments to have a broader view of impact of ECBC code. Apart from the on-ground planning involved in organizing such events, certain back end activities need to be undertaken to prepare the material for the events. Such back end activities, along with the reference material to be referred for completing the specific activity, is given in the table below:

Table 41: Summary of recommended awareness generation activities

S.No.	Activity	Stakeholders to be referred	Description/Reference material

1	Agenda templates for stakeholder meetings	Local government	• PNNL[19] has organized state- and local-level stakeholder meetings to introduce ECBC and gain stakeholders' support. Agenda template from these meetings are provided in the PNNL's Toolkit for ECBC Implementation20
2	Training materials for conceptual understanding	Local government, building owners, building developers, Architects and engineers, Building industry professionals	• USAID and BEE developed ECBC training materials to introduce ECBC basics. • Training modules introducing ECBC requirements are provided • PNNL developed training material for local code officials, which provides a brief overview of ECBC and its benefits
3	ECBC benefit analysis	Local government, building owners, Building developers	• PNNL conducted a benefit analysis for ECBC in Gujarat to show the potential for energy and economic savings in comparison with other building energy programs
4	Pilot building case studies	Local government, building owners, building developers, Architects and engineers, Building industry professionals	• Malviya National Institute of Technology wrote a case study of its on-campus ECBC pilot building[21] • PNNL developed a brochure on the pilot building[22]
5	City-level case studies	Local government	• City-level case studies could help local governments have a big-picture view of how ECBC takes effect and interacts with other dimensions of the city. • Natural Resources Defense Council's report Analyzes and offers recommendations for the Hyderabad buildings sector[23] • A state-level ECBC progress report for Rajasthan by PNNL is also available

Hence, the group of stakeholders given for each activity need to be consulted/interviewed to suitably modify the reference material and make them more relevant to the context of commercial buildings in Odisha. The state can also collaborate with R&D institutions and industry associations like Indian Institute of Architects (IIA) to undertake conferences and workshops to develop conceptual understanding of ECBC and spread awareness of benefit of ECBC using building and city level studies.

Further, Ministry of Power has launched the ECO Niwas Samhita 2018, an Energy Conservation Building Code for Residential Buildings (ECBC-R) in December 2018 (BEE 2018). Initially, Part-I of the Code has been launched which prescribes minimum standards for building envelope designs with the purpose of designing energy efficient residential buildings. Eco Niwas Samhita 2021 (Code Compliance and Part-II: Electro-Mechanical and Renewable Energy Systems) is developed to set the minimum benchmark to achieve energy efficiency in residential buildings. The code is focused on electro-mechanical and renewable services in addition to the envelope parameters as prescribed in Eco Niwas Samhita 2018.

For guidance, the responsibilities for adoption and enforcement tasks to mainstream ECBC are captured in the following matrix:

Table 42: Summary of activities required to implement ECBC

	Responsibilities

[19] PNNL is Pacific Northwest National Laboratory, one of the United States Department of Energy national laboratories, managed by the Department of Energy's (DOE) Office of Science. PNNL scientists conduct basic and applied research and development in multiple fields including increasing the U.S. energy capacity, reducing dependence on imported oil and reducing the effects of human activity on the environment.

[20] For further information, refer: https://www.pnnl.gov/main/publications/external/technical_reports/PNNL-26000.pdf

[21] For further information, refer: https://cleanenergysolutions.org/sites/default/files/documents/ecbc_released_version.pdf

[22] For further information, refer: https://cleanenergysolutions.org/sites/default/files/documents/ecbc_released_version.pdf

[23] For further information, refer: www.globalchange.umd.edu/wp-content/uploads/2016/07/Rajasthan-Impact-Assessment-Report.pdf

Tasks related to mainstream ECBC	Central Government	State Government	Stakeholder departments
ECBC Adoption			
Set-up ECBC committee to implement code		SDA	
Review the ECBC and customization of code to suit regional and climatic conditions		SDA	
Define criteria of applicable building types		SDA	
Make legal notification in the state gazette for mandatory implementation of code		SDA	
Develop enabling mechanisms and processes for mainstreaming ECBC	BEE	SDA	ULBs
Revision of Common Schedule of Rates (CSR)		SDA	
Revision of State General Development Control Rules/ ULB's Building Bye-Laws		SDA	ULBs
Develop ECBC implementation Rules e.g. Third Party Assessor (TPA) Model	BEE	SDA	ULBs
Use public online tools/ endorse third party simulation software to show compliance	BEE	SDA	ULBs
Develop technical capacity of building sector stakeholders	BEE	SDA	ULBs
ECBC Enforcement			
Institutionalize mechanisms for enforcement and compliance checking in ULBs & Electrical Inspectorate	BEE	SDA	ULBs
Set-up of robust Monitoring and Verification (M&V) system	BEE	SDA	ULBs

On part of the consumers, to develop awareness of retail buyers in Odisha on the benefits of energy efficiency for buildings and building labeling programs, the following steps can also be undertaken:

- Conduct outreach programs: Outreach programs can be conducted to educate retail buyers about the benefits of energy-efficient buildings and the building labeling program.
- Collaborate with developers and builders: Collaboration with developers and builders can help ensure that new buildings are constructed with energy efficiency in mind.
- Encourage the adoption of energy-efficient appliances: Retail buyers can be encouraged to adopt energy-efficient appliances by providing information on the energy rating of appliances and their impact on energy consumption.
- Develop consumer-friendly labels: Consumer-friendly labels can be developed to provide information on the energy performance of buildings.
- Incentivize retrofitting of existing buildings: Retail buyers can be incentivized to retrofit their buildings by providing financial assistance or tax credits for energy-efficient retrofits.
- Establish partnerships with energy consultants: Partnerships with energy consultants can help retail buyers identify energy-saving opportunities in their buildings

In conclusion, the implementation of the Energy Conservation Building Code (ECBC) for residential buildings in Odisha can have a significant impact on reducing energy consumption, promoting sustainable development, and reducing greenhouse gas emissions. The development of an implementation roadmap as outlined above can help ensure the effective adoption and compliance with the code, leading to energy-efficient residential buildings in the state. The successful implementation of the ECBC code will require the collaboration and commitment of all stakeholders involved, including government agencies, builders and developers, architects, engineers, and energy consultants. By working together towards this common goal, Odisha can pave the way for a more sustainable future in the built environment.

3. Provide institutional and regulatory support to businesses providing ECBC compliant building material and building energy management system

With the amendments in building by-laws and subsequent notification and incorporation of the Odisha ECBC Rules 2022, compliance with ECBC will become mandatory for construction of new commercial buildings coming under the ambit of the code (Energy Department 2022). This will lead to increased demand for ECBC compliant building materials, solar water heating equipment, comfort systems and controls, specialized experts for designing and constructing ECBC compliant buildings in the state, etc. In the absence of market players providing aforementioned equipment or services, the implementation of ECBC will fail to achieve its desired results. Hence, there is a need to ensure presence of such local market suppliers in Odisha as this is a pre-requisite for ECBC implementation in the state.

In order to undertake the market development, OREDA can undertake pilot studies to establish the market potential arising out of implementation of ECBC in the short to medium term. The studies can provide important information in developing collaterals to reach out to market suppliers providing equipment and services related to ECBC. OREDA can act the leading agency which will co-ordinate and organize the events (roadshows, conferences, exhibitions etc.) for reaching out to the market for developing their businesses in Odisha in the following areas:

- Developing training institutes/conducting certification courses in the state to develop capacities in designing ECBC compliant buildings and assessing compliance of building design with ECBC.

- Establishing manufacturing units/development centres for manufacturing and developing ECBC compliant equipment, material and control systems e.g., ACC limited has set up green centres in various parts of the state.

4. Creation of centres of excellence to promote green buildings and strengthening R&D activities

The state, with the assistance of BEE, can take up innovative research projects in building energy efficiency through educational/ technical and research institutions to promote green buildings in Odisha. On a pilot basis, a centre of excellence can be developed in OREDA having all the available energy efficient building materials used in constructing green/ ECBC building and accordingly, such centres can be replicated in the offices of various key stakeholder departments under ECBC R&D centres.

With various building codes like ECBC and ENS in place, the state is at the stage where a significant impact can be created in the building infrastructure to save energy. With various policy measures and guidelines in place for the residential as well as commercial buildings, a significant energy savings can be realised through improved building infrastructure. With the strict implementation of these codes, the state can save up to 15% of energy in the residential building and up to 25% energy in commercial building space by 2040.

5. Encouraging development of building integrated PV (BIPV)

Building Integrated Photovoltaics (BIPV) is the integration of photovoltaics (PV) into the building envelope. It serves two purposes – firstly, generating clean power and secondly, replacing conventional building materials in parts of the building envelope such as roofs, canopies, curtain walls, skylights or facades with solar PV panels. The installed BIPVs provide shed, block sunlight, and give a modern look to any building, all this while producing electricity from sunlight.

Advantages:

- Acting as both building materials and power generators, BIPV serves the dual purpose of providing a cost-saving option both on construction and electricity bills.
- BIPVs add to the aesthetics of the building in terms of design and appearance as they are available in a wide range of colors, shades, flexibility, and degrees of transparency.
- BIPVs can be used as the safety glass providing an eco-friendly heat protection system for the building.

Crystalline silicon-based (c-Si) solar cells or thin-film technologies such as amorphous-based silicon (a-Si), cadmium telluride (CdTe) and copper indium gallium selenide (CIGS) are some of the materials often utilized in BIPV (Government of Canada 2018). While the main function of a conventional PV system is efficient power generation, the building integrated PV systems become the components of the building envelope.

OREDA has set encouraging examples of BIPV through the installation of BIPV system on several complexes and building. Some of the prominent examples are:

- BIPV Installation at Kalinga Institute of Industrial Technology (KIIT) University: KIIT University in Bhubaneswar has installed a BIPV system on the roof of its new campus building. The system has a capacity of 18 kWp and generates electricity for the building's energy needs.
- BIPV Installation at Green Building Complex: The Odisha State Pollution Control Board (OSPCB) has constructed a green building complex in Bhubaneswar, which includes a BIPV system installed on the building's facade. The system has a capacity of 10 kWp and generates electricity for the building's lighting and ventilation systems.
- BIPV Installation at Odisha State Secretariat: The Odisha State Secretariat in Bhubaneswar has installed a BIPV system on the roof of one of its buildings. The system has a capacity of 32 kWp and generates electricity for the building's lighting and air conditioning systems.

BIPV is not a completely new technology for Odisha.

These are just a few examples of BIPV projects in Odisha. There are likely to be more such projects in the state, as BIPV technology becomes increasingly popular as a sustainable and aesthetically pleasing option for generating clean energy. It is recommended that similar BIPV installations are encouraged in buildings in the state.

To begin with, Government buildings can be targeted for solar integration. BIPV can be installed on building façades in addition to the roof. BIPV modules can generate power by both direct and diffused radiation. As solar panels are glass-based, components that contain glazing such as windows, skylights, glass façades, roofing sheets, tiles and doors can easily be planned to be energy-producing solar panels. In addition to producing electricity, these can enhance energy savings for Odisha due to superior thermal insulation properties and solar radiation control.

In order to support the integration of BIPV technology in the existing buildings, provisions of BIPV technology, its usage, incentives, and mandates can be introduced in the ECBC guidelines. Mandate on using BIPV technology in the newly constructed government, commercial and residential buildings, especially where roof space is limited, will push the adoption of the technology. Tax incentives on the BIPV structures could also facilitate its widespread penetration and usage within the building sector in Odisha. MNRE, Government of India is implementing the solar building demonstration programme whereby financial support for construction of demonstration solar buildings will be provided by the Ministry up to 10% of the cost of construction, subject to a maximum of INR 50 lakhs for each project. Additionally, new commercial buildings can be mandated to incorporate BIPV in their building design.

6. Exploring the possibility of integrating solar glass panels in new commercial and residential buildings

Transparent solar is a cutting-edge technology that gathers and uses light energy through windows or any glass surface and lets visible light pass through while picking up just the invisible wavelengths of sunlight in the ultraviolet and the near-infrared to convert into electricity. This technology has potential to broaden the scope of solar and pave the way for net-zero energy buildings and help cities to meet climate goals and targets considering the very high number of glass surfaces prevalent in building usage. The solar glasses allowing light to pass through it would enrich buildings with the natural light during the day, reducing the use of electricity requirement for building illumination during the daytime. The technology is still relatively new and a lot of research is being carried out to increase its efficiency to make it viable for usage. Presently, highly transparent solar applications are recording efficiencies above 5% (MSU 2017).

Working

Transparent solar glass functions more as a transparent solar concentrator, which means it is made to **absorb specific UV and infrared light wavelengths that aren't visible to the naked eye and transform them into energy capable of powering electronics**. This technology is also called **photovoltaic glass**, and it's manufactured to provide a **ranging level of transparency** (Interesting Engineering, Inc. 2022). Hence, a trade-off needs to be established between efficiency and transparency for its usage in building applications.

The demand for glass as a construction material is growing rapidly in India with the increased urbanization, construction of shopping malls, MNCs, high-rise buildings across the country. The State of Odisha can have an early mover advantage in adopting solar glass in the new construction of its glass buildings. With the good available solar radiation (5.5 kWh/m2/day) with around 300 sunny days in a year (Science and Technology Department 2013), solar glass has huge potential to capture the energy needs of buildings.

Emerging usage

- There have been applications of the usage of transparent solar glass structures globally. For example, Biomedical and Physical Sciences Building on the campus of Michigan State University was upgraded with the installation of 100-square-feet transparent solar glass panels which were situated above the building's entryway and generates enough electricity to power the lighting in its atrium (MSU 2021).

- The Copenhagen International School's design also uses 12,000 hued but clear solar panels all over the building, **producing 200 MWh of energy annually** – more than half of the energy the building consumes. The solar cells cover a total area of 6,048 square meters making it one of the largest building-integrated solar power plants in Denmark (CF Moller 2017).

7. Integrating solar rooftop in community health centres and primary health centres in rural areas in Odisha

The effectiveness of healthcare delivery depends immensely on the availability of power in healthcare facilities. Vital elements such as transportation, stockpiling of immunizations, provision of clean water, emergency services, and the ability to retain staff all hinge on power availability. Additionally, having backup electricity is crucial for ensuring that medical equipment continues to function during a power failure at a health centre.

Healthcare facilities, especially in rural Odisha, are reeling under the impact of frequent and unscheduled power cuts (Odisha TV 2023), despite being the local communities' first point of contact for healthcare services. The provision of a reliable energy supply in healthcare facilities has the potential to substantially enhance the quality of care.

The state could start with solarizing the primary healthcare centres in the state. The community health centres and primary health centres in the all the districts together have a rooftop area of 24,537.37 Sq. mt. Based on the following assumptions, **1.43 MWp of solar PV can be installed through solarization of CHCs and PHCs in the state**:

- Assumption taken that all the PHCs and CHCs can be solarised through rooftop solar installation
- Assumption taken that 70% the available rooftop area can be used to install RTS systema and 30% area reserved for amenities.
- For RTS projects, 12 sq. mt. of rooftop space requirement is taken for development of RTS of capacity 1 kW (MNRE).

Here learnings could be drawn from Chhattisgarh where the Chhattisgarh State Health Department collaborated with Chhattisgarh Renewable Energy Development Agency (CREDA) to solarise all the primary healthcare centres in the state[24].

A total of 900 health centres, assisting approximately 80,000 individuals every day were solarised. By ensuring a consistent energy supply, healthcare centres are able to provide therapy round the clock, enabling them to cater to a greater number of patients. Regular electricity has made it possible to have reliable water supply, secure vaccine refrigeration, and power essential equipment like theatre equipment, fans, and baby warmers. This has resulted in a fourfold increase in the number of new-borns delivered at these facilities, as women can now safely give birth at night. Additionally, reliable power enables the digitization of patient services, leading to a significant improvement in operational efficiency. When compared to the grid or backup diesel, solar systems have resulted in an 80% reduction in energy costs, while also helping the patients with quality health services (JREDA, CEED & Power for All 2022).

8. Encouraging development of sustainable hospitals in urban areas

At present, Odisha has 15 Area Hospitals, 32 District Hospitals, 21 Sub-divisional Hospitals and 10 Special Hospitals (Odisha Online 2023). These hospitals consume enormous amounts of energy, mainly due to their 24/7 operations, air conditioning, lighting, and medical equipment. To incorporate energy efficiency measures in these hospitals, the implementation of energy-efficient practices, such as utilizing LED lighting, smart HVAC systems, and energy-efficient medical equipment must be explored. These measures can have a substantial impact on reducing energy consumption and decreasing operating costs. For example, the installation of energy-efficient lighting in the operating room alone can result in energy savings of up to 60%.

Going beyond this, hospitals can embrace a green thinking approach, emphasizing sustainability in their operations. This approach entails minimizing waste generation, adopting circular economy practices for recycling, and utilizing environmentally friendly products. This includes starting with installing solar rooftop on the hospital building to exploring the possibility of integrating BIPV in the building envelope. Construction of solar parking sheds could also be explored in these hospitals for meeting some part of the electricity needs.

Solar Carport installed by TATA Motors

Tata Motors and Tata Power constructed grid-synchronized, behind-the-meter solar carport at the Tata Motors car plant in Chikhali, Pune (TATA Motors 2021).

Parameter	Value
Area	30,000 square meters
Capacity	6.2 MWp
Electricity generation	86.4 lakh kWh of electricity per year
CO2 reduction	7,000 tons of carbon emission reduction annually and 1.6 lakh tons over its lifecycle

Another part of the green thinking approach would include management of waste generated at the Hospitals. They produce a considerable volume of waste, which includes hazardous materials like infectious waste and medical waste. Implementing efficient waste management strategies can minimize the environmental impact of hospitals while safeguarding public health. Hospitals can adopt waste reduction strategies such as recycling, composting, and waste-to-energy. By setting waste-to-energy solutions, hospitals can transform waste into usable energy, thereby reducing the amount of waste sent to landfills and lowering greenhouse gas emissions. They could also establish an arrangement with the municipal corporation of the area for collection of the bio-medical waste and supply of the same for waste-to-energy plants in the vicinity.

Here, one of the key requirements would also be to conduct environment audits for hospitals for safe handling of hazardous waste. CPCB has notified Hazardous and other Wastes (Management & Transboundary Movement) Rules, 2016. The purpose of notifying these rules is to ensure the safe handling, generation, processing, treatment, packaging, storage, transportation, use, reprocessing, collection, conversion, offering for sale, destruction, and disposal of hazardous waste. As

[24] https://www.powerforall.org/application/files/2016/6074/5141/DRE_Booklet_final_1.pdf

such, it is pertinent to understand whether these rules are being followed by hospitals. On the other hand, environmental audit shall offer hospital management a focused chance to assess whether the facility has established and upheld a system to achieve and sustain compliance, while identifying and rectifying any instances of non-compliance. As such, hospitals should be encouraged to undertake environmental audits to streamline their process for hazardous waste management and ultimately, reduction. Odisha State Pollution Control Board could be assigned the responsibility of creating awareness among hospitals about the need to conduct environment audits and the benefits of the same.

Although constructing sustainable hospitals may involve substantial initial expenses, they can lead to long-term cost savings. Energy-efficient buildings incur lower operating costs, resulting in reduced energy bills for the hospital. Additionally, implementing waste reduction strategies can help minimize waste disposal expenses. Furthermore, incorporating sustainable design elements like natural lighting and ventilation can enhance patient outcomes, leading to lower readmission rates and decreased healthcare costs.

9. Deployment of innovative renewable energy solutions for the tourism sector

The government can encourage the tourism sector in Odisha to shift towards renewable energy sources by promoting the installation of solar photovoltaic (PV) systems on the rooftops of hotels, resorts, and other tourist facilities to generate clean electricity. The state can explore several innovative renewable energy solutions for building design such as building integrated solar PV (BIPV), solar glass panels, solar parking sheds, solar rooftops, etc. for hotels and other locations. Furthermore, major tourist cities can be converted into solar towns (like Konark) by installing solutions like solar streetlights on major roads, solar-powered drinking water kiosks / ATMs, etc

The following initiatives and support can be undertaken by the government to exploit maximum renewable energy potential for all tourism infrastructure in Odisha:

- **Policy and Regulatory Support**: The government can enforce policies that promote renewable energy integration in the tourism sector and provide requisite incentives and financial support to tourism businesses including subsidies, tax benefits, and low-interest loans to install renewable energy systems.
- **Promote the use of EVs** – The government can promote the use of electric vehicles (EVs) at all tourist places and convert most of the public vehicle fleet to EVs for example, solar-powered boats have been deployed in an ecotourism spot in Kozhikode district close to the Malabar Wildlife sanctuary.
- **Capacity Building:** The state can provide training and capacity-building programs for tourism stakeholders to enhance their understanding of renewable energy and sustainable practices. The government can launch public awareness campaigns to educate tourists about the importance of sustainable energy practices and encourage their participation in conserving energy during their stay.
- **Monitoring and Evaluation:** Regularly monitor the energy consumption and performance of tourism facilities to track the effectiveness of implemented energy-saving measures and evaluate the success of the Energy Plan periodically and make necessary adjustments based on the results to ensure continuous improvement.

Lastly, the government can explore the feasibility of using small-scale hydropower and biomass energy systems where appropriate and facilitate partnerships between tourism stakeholders and renewable energy companies to establish solar farms and wind energy projects in suitable locations (for example, an agreement has been signed between the government in Bihar and Solar Energy Corporation of India to provide hybrid renewable energy for tourist places such as Bodh Gaya and Rajgir).

10. Facilitating rapid developments in innovative solid and liquid waste management to manage waste resulting from tourist activities

Odisha can invest in the development of efficient waste management infrastructure and facilities specifically designed to handle the waste generated by tourist activities. This includes establishing recycling centres or stations at key tourist sites, hotels, and restaurants and promoting responsible tourism practices. The state can establish tie-ups with municipal corporations to provide most of the segregated waste as raw material for bioenergy projects in the state and then set up decentralized biogas to power projects to fulfil the energy needs at tourist locations.

Furthermore, local communities should be educated on the importance of waste management and the proper separation and disposal of waste. This can be achieved through signage, brochures, and interactive sessions at tourist attractions, hotels, and information centres. By combining these efforts, Odisha can create a comprehensive waste management system that addresses the unique challenges posed by tourist activities. This will not only ensure the cleanliness and sustainability of tourist destinations but also contribute to the overall environmental well-being of the state.

11. Promote and ensure the use of renewable energy for all of the sports infrastructure across rural and urban areas

Odisha can promote the use of renewable energy solutions for building design in various sports facilities or complexes across the state such as passive solar building complexes, solar rooftops, solar parking, decentralized heat pumping systems, etc. The government should ensure that all existing large sporting events in the state are powered by renewable energy. Additionally, the following steps can be undertaken to encourage the use of renewable energy in the sporting sector of the state:

- **Mandatory Renewable Energy Integration:** Enact policies and regulations that mandate the use of renewable energy for all new sports infrastructure projects in Odisha. This can include requirements for a certain percentage of the energy consumed by sports facilities to be generated from renewable sources, such as solar or wind power.
- **Incentives and Subsidies:** Provide financial incentives, subsidies, and tax benefits to sports organizations and facility owners who invest in renewable energy systems. This can include reduced tariffs or special rates for renewable energy generated by sports infrastructure can encourage wider adoption.
- **Public-Private Partnerships:** Foster collaborations between the government, sports organizations, and private renewable energy developers to establish partnerships that promote the development and operation of renewable energy projects specifically for sports infrastructure.
- **Technical Assistance:** Provide technical assistance and capacity-building programs to sports facility owners, managers, and engineers. This can include training on renewable energy system design, installation, operation, and maintenance. By enhancing the knowledge and skills of relevant personnel, the adoption of renewable energy in sports infrastructure can be facilitated.
- **Effective waste management:** Establish partnerships with waste management agencies and local recycling initiatives to develop efficient waste collection and disposal systems and promote the use of reusable and eco-friendly alternatives i.e., biodegradable, or compostable materials for food and beverage packaging in sports venues instead of single-use plastic.

By implementing these strategies, Odisha can create a conducive environment for the widespread adoption of renewable energy in sports infrastructure. This will not only contribute to reducing carbon emissions but also position Odisha as a sustainable and environmentally conscious destination for sporting events and activities.

12. Develop and encourage sustainable transportation options for sports events and activities

To provide efficient and convenient transportation options for participants and spectators attending major sports events, Odisha must develop a comprehensive transportation plan that includes shuttle services, electric or hybrid vehicle fleets, and well-connected public transport routes. The government should promote the use of low-emission public transportation by offering discounted or free fares for ticket holders, coordinating shuttle services from major transportation hubs to event venues, and ensuring reliable and frequent schedules.

Additionally, the state can encourage the use of active and non-motorized transportation modes for shorter distances by collaborating with event organizers to promote walking and cycling as viable transportation options and offer incentives for participants and spectators who choose these sustainable modes of transport. To implement this, Odisha must develop and enhance pedestrian and cycling infrastructure such as dedicated lanes, establish bike-sharing programs near sports venues, and encourage athletes and spectators to use the same.

By prioritizing sustainable transportation options, Odisha can reduce the reliance on private vehicles and minimize the environmental impact associated with sports events and activities. This approach not only contributes to the

state's environmental goals but also enhances accessibility and promotes healthier lifestyles among participants and spectators.

13. Renovate and reconstruct sports facilities in Odisha with a focus on green building principles

There are several ways to reconstruct or renovate sports facilities in Odisha with a focus on green technology for example, Odisha can implement rainwater harvesting systems in sports complexes to conserve water resources and use recycled or treated water for irrigation purposes to reduce the strain on freshwater sources. Recently, in the Men's Hockey World Cup, all the pitches used in Rourkela and Bhubaneshwar were Poligras surfaces, i.e., bio-based polyethylene turf made from renewable resources such as sugarcane. Poligras also used modern technology, which enabled less use of water on the turfs (60-70% less water than what was used in the Sydney 2000 Olympic Games)[25]. This ground-breaking technology coupled with other green initiatives, can be used to develop playing surfaces for other sporting events in Odisha including the Hero ISL (major football event).

Therefore, Odisha can renovate and reconstruct sports facilities using innovative technology and renewable raw materials in an environmentally friendly and sustainable way.

14. Continue to undertake the energy conservation buildings awards to incentivize uptake of energy efficiency and energy conservation

For promotion & awareness of ECBC and energy conservation in general, State Energy Conservation Award specifically for ECBC should continue to be given to the consumers of industrial, commercial, government buildings, educational institutions, hospitals, municipal committees / corporations and individuals who have excelled in adopting the various energy conservation measures in their buildings / units to save electricity / other fuels. To increase the participation, OREDA can reach out to the building departments namely, Department of PWD (B&R), OUHM, GMADA, Department of Local Government, Health Corporations, etc.

Odisha is already undertaking energy conservation award programs in the state. In 2015, the state launched the Odisha State Energy Conservation Award (OSECA) to promote a state level recognition to the selected entities (only commercial buildings having connected load of 50 kW or above are eligible to participate in the award) that have made systematic and continued attempts for efficient utilization and conservation of energy in previous years (OSECA 2022).

By 2022, **Infosys Development Centre Bhubaneswar** received OSECA for the 5th time in a row, for taking effective initiatives to conserve energy. The recognition bestowed upon Infosys Development Centre in Bhubaneswar for their effective initiative to conserve energy, as evidenced by the OSECA (Odisha State Energy Conservation Award), presents an opportunity for the state government of Odisha to draw valuable learnings and replicate such initiatives on a larger scale. To begin with, the government can initiate a collaborative partnership with Infosys to gain in-depth insights into their energy conservation practices, including the strategies, technologies, and best practices employed. Conducting site visits, engaging in knowledge-sharing sessions, and organizing workshops or seminars with the officials and experts from

The government can also establish a dedicated task force or committee to analyze the feasibility of implementing similar energy conservation measures in various government buildings, institutions, and public infrastructure. Furthermore, integrating energy conservation practices and awareness programs into the curriculum of educational institutions, conducting awareness campaigns for citizens, and providing incentives or recognition for outstanding energy-saving initiatives can help promote a culture of energy conservation across the state. By harnessing the expertise and experiences of Infosys, the state government of Odisha can create a framework for sustainable energy conservation initiatives, thereby contributing to a greener and more environmentally conscious future for the state.

[25] https://sportstar.thehindu.com/hockey/hockey-world-cup-2023-astro-turf-pitches-playing-surfaces-water-usage-eco-friendly-odisha-rourkela-bhubaneswar/article66387236.ece

15. Undertake replacement of inefficient electrical equipment/ appliances with BEE star labelled energy efficient appliances and solar water heaters in buildings

OREDA, with the assistance of BEE, is already replacing existing appliances and lighting with energy efficient variants under demonstration projects in the public buildings. Hence, to increase the annual energy savings and coverage of buildings, a target oriented approach shall be initiated wherein, different categories of commercial buildings can be taken up as the demonstration projects and the same may be replicated by the individual departments.

To start with, sample survey of the commercial buildings owned by public departments shall be conducted to assess the penetration, type, rating, etc. of existing appliances along with their operating hours and annual electricity consumption (kWh). Accordingly, the number of buildings shall be selected in such a way that all the commercial building categories are covered in the first phase of implementation. The next step shall be to conduct the energy audits for assessing the potential energy conservation measures. Such planned and target-oriented studies shall help the state government to monitor, track and calculate the exact impact of savings and accordingly, reach out to the larger set of buildings.

In the medium to long run, periodic energy audits (at least every 5 years) for all government buildings, which are delivering public services, are needed to be undertaken. Periodic energy audits are to ensure that appliances, lighting, fans, etc. continue to operate efficiently throughout a building's lifespan, allowing building owners to continuously rEP energy saving benefits. On the basis of the results of these energy audits, energy efficiency and renewable energy measures suggested in this section can be implemented in the State. Furthermore, information on energy auditing and related practices should be prepared and disseminated to the public sector buildings. Conducting these energy audits in government buildings and disseminating this information could be the responsibility of Energy Transition Committee under CS.

To conduct these energy audits, it will be paramount for SDA to provide guidelines for energy auditors regarding the key elements for preparing for an energy audit, conducting an inventory and measuring energy use, analysing energy bills, benchmarking, analysing energy use patterns, identifying energy-efficiency opportunities, conducting cost-benefit analysis, preparing energy audit reports, and undertaking post-audit activities. As such, building capacity of the officials to undertake such audits in the need of the hour. The specific capacity building measures that can be undertaken are provided above, in recommendation no. 2 for building sector.

16. Develop awareness of retail buyers on the benefits of energy efficiency for buildings and building labelling program

In order to spread awareness among retail consumers on energy efficient appliances, a web tool has been developed as part of the State Action Plan. This web tool can be hosted on the website/mobile phone application of OREDA. The web tool can provide the consumers with detailed analysis on the impact of using energy efficient application on power consumption charges as well as discounted payback period for the investment made on the appliance. Details on the web tool is provided in the section on cross-sectoral activities. The web tool can later on be expanded to serve as the means of developing awareness around energy labelling for residential buildings, introduced by BEE.

17. Develop implementation roadmap for demand side management (DSM) and demand response (DR) programs

Demand Side Management (DSM) measures in the energy sector is a cost-effective tool. As a customer strategy, DSM programs encourage the installation of end-use technologies that consume less energy, thereby reducing and/or shifting the customers' overall electric bill. The DSM programs namely, replacement of inefficient fans with BEE 5 star labelled energy efficient BLDC ceiling fans, Refrigerators, ACs, lighting may be implemented in the state and accordingly the replicability may be initiated in other sectors as well.

On the other hand, Demand response (DR) is a strategy used by electric utility companies to reduce or shift energy consumption from peak hours of the day, when the demand for electricity is the highest to leaner demand periods. It involves allowing customers to choose non-essential loads, which can be shed by the customers themselves or by the utility, at peak times. It is a pre-arranged agreement between the Utility or intermediate agencies like aggregators with the consumer with specific conditions of load, price and time intervals.

BYPL has successfully carried out a pilot for manual Demand Response in 2017-18 & again in 2018-19. The pilot program succeeded in triggering awareness amongst the consumers about energy efficiency. DR is a crucial DSM measure that grid managers can also use for managing peak demand. A typical DR program offers several benefits to all the stakeholders involved. It also provides spin-off benefits to the non-participating customers by reducing costs of the licensee, thus translating into decreasing tariffs. (Compendium on DSM measures undertaken by DISCOMs 2021). An annual electricity savings of 0.05 MUs with a peak demand reduction of 17 MW (April 2017 - June 2017) and 32.5 MW (June 2018–Oct

There are various types of DR program being implemented globally as well by utilities with varying forms of incentive structure, pricing strategy, implementation model, capital requirements etc. Broadly these programs can be classified into three categories based on the sophistication of technology involved.

- **Manual DR Program:** In this case, the consumer responds to the utility's request by manually switching off the electrical equipment at their premises. The utility does not exercise any control over the demand curve of the customer, and hence it is an entirely voluntary program.

- **Semi-Automated DR program:** In this case, selected electrical equipment at the consumer facility is connected to an energy management system to switch off automatically or reduced usage of this equipment. Under such a program, the utility exercises some control over the consumer's demand and may switch it on / off as per requirement.

- **Fully Automated DR program:** In this case, all the electronic equipment in the consumer premises are integrated with energy manages systems which, in response to the utility's request, automatically switch off or reduced usage of selected equipment. In such a program, the utility exercises complete control over the demand of the customer. It also has limitations on the extent of load relief that any participant may provide as the same is pre-decided while installation of the ADR system at the consumer premises. This limits the utilization of the entire load for securing DR relief from the concerned consumer.

In 2019, a pilot demand side management response program was implemented by Bangalore Electricity Supply Company Limited (BESCOM) in collaboration with Tata Power Delhi Distribution Limited (TPDDL). Under this project, BESCOM and TPDDL implemented several demand response measures, including the deployment of advanced metering infrastructure (AMI), implementation of time-of-day pricing and critical peak pricing, and the development of a mobile application for consumers to manage their energy consumption. The pilot project was successful in reducing peak demand by 6-10% and energy consumption during peak hours by 10-12%. The project demonstrated the potential for demand response programs to reduce peak demand and improve energy efficiency,

While the DISCOM can gain significantly from the implementation of DR, there are a number of requirements for creating such a system. It is advised that DRS be implemented for the state over the medium to long term because the development of the system depends on the installation of smart grid components.

6.7. Cross-sectoral initiatives

In order to implement the core activities provided under the Action Plan there are a number of supporting activities/initiatives that need to be undertaken which are cross-sectoral in nature. This section provides a brief description of such activities/initiatives.

1. Exploring convergence between Mission Shakti and Odisha Electric Vehicle Policy in Transport sector

Empowerment of women is one of the key development initiatives identified by the Government of Odisha. The correlation between economic empowerment and social empowerment of women is widely recognized. Consequently, utmost importance has been placed on assisting women in attaining economic independence through the facilitation of independent employment and income avenues for them. As such, as a crucial approach to women's empowerment, the promotion of Women's Self-Help Groups (WSHGs) was adopted under the 'Mission Shakti' program in 2001. The program has a clear goal of empowering women through profitable ventures by offering credit facilities and establishing market linkages (Department of Mission Shakti 2001).

Recently Mission Shakti has ventured into rural transport with e-autos, setting a new trend in women empowerment and clean energy in the state (Department of Mission Shakti 2022). The scope of this initiative can be expanded to include e-buses and e-taxis. Synergies could be drawn from Delhi where the Delhi Government, along with Delhi Transport Corporation, is encouraging women to become professional taxi and buses drivers. The Government has launched a scheme under which it is bearing 50% of the cost of the driving training for women (The times of India 2022). As part of Mission Shakti, women can be capacitated to become professional drivers and emerge as e-taxi and e-bus drivers in addition to e-cab drivers. This initiative shall bode well with the objective of Mission Shakti in terms of helping women attain economic independence through the facilitation of independent employment and income avenues for them.

The content for professional training courses could also be taken up as part of course / curriculum development envisaged as part of Renewable Energy Research Institute. GoO could also look to on-board fleet owners and aggregators who could potentially sponsor part of the fees for these courses and employ the women drivers after the on-the-job trainings. The State Government could work with these companies to set up a mechanism so that women trained through the initiative could receive guaranteed jobs in these companies.

2. Creating avenues for women entrepreneurship in the food and milk processing sectors under the Odisha Livelihood Mission Of Mission Shakti

Odisha Livelihoods Mission (OLM) is an autonomous society under the aegis of Department of Mission Shakti, Government of Odisha, presently implementing both National Rural Livelihoods Mission and National Rural Livelihoods Project (Odisha Livelihood Mission 2023). Given these objectives, a convergence could be drawn between Mission Shakti and OLM to propagate development of women entrepreneurs in the cold chain and milk processing sectors in the State. The need for augmenting such infrastructure is also substantiated from the fact that:

- The overall fish production from all sources in Odisha has more than doubled between 2013-14 and 2021-22 and registered a CAGR of 11.5 % during the same period and stood at 9898 thousand MT in FY22 (Economic and Statistical Organisation, Governement of Odisha 2022).
- The milk production in Odisha has increased from 1903 thousand MT in 2014-15 to 2402 thousand MT in 2021-22. There has been a rise in the per capita availability of milk from 114 gm/day in 2012-13 to 135 gm per day in 2021-22 (Economic and Statistical Organisation, Governement of Odisha 2022).
- Fruit production stood at 2782.05 thousand MT in FY22 and 9523.71 thousand MT in FY22 in the State (Ministry of Agriculture 2022)

Odisha is known for its 10 Agro-climatic zones and 8 major soil types, which are favourable for the production of a variety of crops, vegetables, fruits and spices. As can be assessed, the food and milk processing sectors in Odisha holds significant potential for growth and women employment. Recognizing this, the Government of Odisha is committed to offering the necessary infrastructure, institutional support, and fiscal incentives to enhance value addition in the sector.

Already Odisha has 'Odisha Food Processing Policy, 2022' in place to increase the flow of private sector investments across the value chain from farm gate to market. The Policy provides fiscal & non-fiscal incentives,

infrastructure development, skill development and cluster approach for the development of the sector (MSME Department 2022). The policy also encourages and enables local entrepreneurs to setup food processing enterprises. Working together, Department of Mission Shakti and MSME Department could create avenues for women entrepreneurship in setting up grid connected and off-grid solar cold storage units to store horticulture and fish produce and solar milk chillers in the State. The fiscal & non-fiscal incentives available under the 'Odisha Food Processing Policy, 2022' could be made available to these women entrepreneurs to set up clean energy based cold storage units and milk chillers in the rural areas closer to farm gate. To make the procurement of such units affordable and lucrative for women SHGs, Department of Mission Shakti could facilitate bank credit linkage to these SHGs for investment in these clean energy systems at farm gate.

Such a convergence could foster an enabling environment and develop supporting infrastructure for the sustainable, equitable, and inclusive growth of the sector, with a view to add value & reduce wastage and thereby, maximizing employment opportunities for women and increasing the income of women farmers.

3. Creating avenues for women employment under Mission Shakti in the electricity sector

SHGs in some districts in Odisha are handling electricity meter reading, billing and collection of electricity charges and are bringing about a paradigm shift in the functional efficiency of the power sector. In various districts, over 1000 groups are actively involved, resulting in improved bill collection, prevention of meter tampering, and enhanced transparency throughout the process. These SHGs get remuneration and incentives based on their achievements. This initiative has been remarkably successful, establishing the SHGs as the go-to resource in villages for managing power outages and addressing minor electricity-related concerns.

An integration of such a mechanism with renewable energy projects in the State could be thought of. To scale up this initiative, the Department of Energy, GoO could bring such women on their payroll and provide them with on-the-job trainings to act as local O&M technicians for existing and upcoming state-owned renewable energy projects. Professional trainings could also be provided to this segment of women by tying up with Skill Council for Green Jobs (SCGJ) which is already catering to the skill requirements of service users, manufacturers, and service providers within the green business industry in India. SCGJ already provides training courses for solar PV installers, Solar PV Manufacturing Operator, Solar PV Project Helper, recyclable waste collector and segregator, animal waste manure aggregator, biomass depot operator, agri-residue aggregator etc. with minimal educational qualification requirements. These courses by SCGJ could be made available for these women to encourage their technical skill development and for providing them with employment opportunities in the sector.

4. Raising awareness & capacity building of demand sectors in energy efficiency/conservation

While a wide range of energy conservation and energy efficiency initiatives are possible with compelling outcomes and impacts, the critical factor in all of these initiatives is the participation of the beneficiaries. Even though some options provide considerable financial benefits, apart from environmental and socio-economic benefits, these options are not actively taken up by the end-users viz. uptake of solar pumps in agriculture, development of agro PV on farmland, energy efficiency methods in MSME, uptake of energy efficient appliances, etc. In each case, there are unique issues which prevent the mainstreaming of renewable energy, energy efficient and energy conservation initiatives.

In order to understand the issues of the beneficiaries and to address these issues adequate awareness and capacity building measures need to be designed and implemented. Such measures have been elaborated under the sub-activities of each specific sector.

5. Exploring convergence between State Rural Livelihood Mission and Policy for developing and promoting Decentralised Renewable Energy Livelihood Applications

DRE-powered livelihood solutions have the potential to reduce and eventually eliminate the reliance of livelihoods on diesel and can supplement the grid supply in Odisha. There are successful pilots and business models of DRE livelihood applications in agriculture, agro-processing, dairy, poultry, tailoring, etc., which have been tested at the field level by various agencies across India and can be replicated in Odisha as well. Some of

these applications include standalone solar cold-storages, off-grid solar deep freezers, solar-biomass hybrid mini / micro grids, off-grid solar pumps, solar cooking systems, solar charkhas (looms), etc.

Various Departments at the state level such as Department of Rural Development and Panchayat, Department of Social Security and Development of Women and Children, MSME-DI, Department of Agriculture, Department of Health & Family Welfare, etc. are implementing schemes in Odisha that support livelihoods directly or indirectly. Integration of DRE livelihood applications with these schemes will promote the use of such applications. GIZ is already working with MNRE at the national level to elucidate the role of decentralised renewable energy in livelihood development. Synergies can be drawn with GIZ on that front in Odisha as well.

Promotion of DRE livelihoods applications becomes even more relevant because of their potential to create sustainable jobs in Odisha. Odisha Government has a role to play in enabling a market-oriented ecosystem to attract the private sector investment for the development and deployment of reliable and affordable DRE based livelihood applications in the state. Since DRE powered solutions are capital intensive in nature, financing for the end-users and enterprises would be critical to enable the adoption of solutions and scaleup of the sector. Odisha has allocated INR 50 crore for Odisha Renewable Energy Development Fund to promote renewable energy development in the state. This fund can be used to finance such projects. For agriculture related DRE livelihood solutions, AIF could also be utilized. This shall boost their confidence in adopting such innovative solutions aimed at improving their agriculture productivity.

6. Exploring convergence between Blue Revolution Scheme and enhancing productivity through the use of renewable energy solutions

Fisheries Department in Odisha could explore tie ups with the National Fisheries Development Board (NFDB) in India for promoting utilisation of renewable energy (such as solar pumps, solar aerators, solar dryers, etc.) in various fisheries and aquaculture activities in the state and undertaking R&D activities for integrating solar in fishing vessels. The Blue Revolution scheme offers subsidies for development of brackish water aquaculture. Integration of solar pumps and solar aerators, in association with NFDB, could be explored for development of aquaculture.

Further, the Fisheries Department encourages development of coastal aquaculture clusters with basic infrastructure such as ice plants, cold storages, etc., in PPP mode. To promote setting up of solar-based cold chain infrastructure for fishery sector in the state, synergy could be drawn with 'Odisha Food Processing Policy, 2022' which promotes private sector investment in the sector by providing fiscal & non-fiscal incentives, infrastructure development, skill development and cluster approach for the development of the sector (MSME Department 2022). This shall be a good opportunity where the private entrepreneurs and small-scale aquaculturists can coexist.

For capacity building of fishermen on how to operate and maintain these solar based systems, NFDB could be on-boarded by the Fisheries Department to provide necessary trainings, exposure visits, refresher courses, extension services and advisory to increase levels of knowledge, skill and expertise among the fishermen community.

7. Developing a biomass trading platform

To mitigate the effects of biomass residue burning on the environment and to establish a streamlined price mechanism for biomass procurement, there is a pressing need to set up a trading platform / marketplace for biomass trading in Odisha. Thus, the main scope for intervention here includes collection and mobilization of the raw material to the plant / industry which could be facilitated by a biomass trading platform. GIZ is already working in the space to develop a framework for biomass trading platform at the national level. Synergies could be drawn with GIZ to develop something similar at the state level.

On the supply-side, development of a biomass platform to collect and process biomass has the potential to generate additional employment opportunities in rural areas and increase the source of income for farmers supplying the biomass. On the demand side, a trading platform shall mean regular and consistent biomass supply for industries. In the absence of formal trading platform / exchange, ensuring high levels of transparency and

clear regulatory frameworks is necessary to reduce uncertainly for economic agents and build trust between them, which often becomes difficult. This can incentivise the development of the biomass sector.

8. A Cross-Sectoral Steering Committee Monitored Implementation of Biomass-based Pilot Projects

A Steering Committee-led monitoring for biomass-based pilot projects (power production, CBG production, etc.), which are laid out for implementation within next 3 years could help in accelerated adoption of biomass. Projects of various types, based on the priority, could be identified, and time-bound actions must be ensured. The Inter-ministerial core group for monitoring could include GRIDCO, OREDA, Department of Agriculture, Department of Power, Department of Health & Family Welfare, Department of Rural Development formed with participation of key stakeholders from the private sector. Further, Odisha Government could make land available to the private developer at zero-cost (especially waste land) and offer the same for biomass-based projects. Larger impetus should be given to this sector, with involvement of all stakeholders for bioenergy projects across the state in order to achieve fulfilment of the applicable SDGs with focus on rural development and sustainable job creation.

9. Integrating Renewable Energy in Healthcare Sector in Odisha

Odisha can look at integrating RE in its healthcare system. One way to do this is to solarize the health centres. Chhattisgarh is an Indian state that solarized most of its health centres. However, to successfully replicate Chhattisgarh's policies in Odisha, it must formalize cooperation between health department, GRIDCO and state DISCOM to identify health centres in need of solarization. It will create a sustainable health system in the state with access to reliable electricity, especially in rural communities. The RE options that can be availed by health centres could include off-grid solar rooftop systems for serving electricity load in the centre, solar water heaters for serving the hot water needs at the facility, standalone solar cold storages / solar deep freezers for storing vaccines, etc. Further, green hydrogen fuel cells could also be used at the health facilities for supply of electricity, heat, and oxygen to the facility. Hydrogen production, compression and storage components of the project could be installed at the premises. The electricity, heat and oxygen supply component could be connected to the 11kV feeder at the health centres. SECI has taken out a tender for a similar technology for a hospital in Leh, Ladakh (SECI 2022). Synergies could be drawn with this project. Collaboration could also be explored with SECI for similar initiatives in Odisha.

10. Collaboration with National/International Partners

Odisha can further leverage the business promotion platforms such as Invest Odisha and International Business Summits to showcase the initiatives undertaken and existing opportunities to improve energy conservation and efficiency and to seek funding or technical assistance for specific initiatives in the clean energy sector. This can potentially create investment options and help to increase engagement with international partner countries or national organizations to enhance economic activity in the state as well as achieve better results in energy conservation efforts being undertaken by the state.

There are four types of collaboration/partnerships that the state can undertake to help reach its energy vision as given below:

a) **Technology collaboration**: In this case, the partner will provide access to innovative technology and solutions to their counterparts in the state.
b) **Investment partnership**: In this case, the state provides the partner with the opportunity to invest in setting up manufacturing facilities in the state.
c) **Knowledge partnership**: In this case, the state provides an opportunity to universities/technical institutes to collaborate with the state, national and international educational/technical training institutes to develop and impart technical courses to build capacity in the state in a particular area or to undertake R&D activities.
d) **Access to markets**: Here the state provides companies, undertaking supply of services and equipment related to clean technology and processes, the access to local market to setup up their businesses.

The areas where the state can look for opportunity on collaboration is given below:

Table 43: Summary of collaboration opportunities for Odisha in energy sector

S.N.	Sector	Area	Type of Collaboration
1.	**Green Hydrogen**	• Manufacturing of electrolyser • Green hydrogen production • Establishing Odisha has green hydrogen hub in India • Manufacturing green ammonia • Establishing infrastructure for adoption of green hydrogen in steel, heavy-duty long-haul trucking, ammonia and refinery sectors	Investment partnership/ Technology collaboration
2.	**Solar**	• Manufacturing of solar panels • Manufacturing of bifacial solar panels for development of agro PV • Manufacturing/assembly of supporting power • equipment required for solar rooftop viz. bi-directional meter, isolation transformers, inverters, protection devices	Investment partnership/ Technology collaboration
3.		• Supply of solar PV panels and supporting power equipment • ESCO services for installation and maintenance of rooftop solar systems • ESCO services for installation and maintenance of agro PV systems • Stand-alone installation and maintenance services	Access to market
4.	**Power transmission and distribution**	• Manufacturing and installation of power transmission equipment viz. digital switch gear and smart substations • Manufacturing and installation of power distribution equipment viz. smart meters, smart controllers, Remote • Terminal Units, SCADA systems, distribution transformers, aerial bundled (AB) cable, meters with • Low Power Radio Frequency (LPR) communication capabilities	Investment partnership/ Technology collaboration
5.		• Grid and transmission line expansion to account for increased consumption of electricity	Access to market
6.		• Technical expertise for assessment of grid synchronization and smart grid installation	Technology collaboration
7.	**Electric Vehicles**	• Assembly and manufacturing of EV components	Technology collaboration / Investment partnership
8.		• Installation and maintenance of EV charging stations • Service providers for vehicle repairing facilities	Access to market
9.		• Expertise for technical assessment of sites for EV charging • R&D on improved manufacturing techniques for EV/EV components	Knowledge partnership
10.	**Energy efficient services**	• Designing energy efficient building • Technical expertise for developing energy optimization systems • Development and implementation of industrial energy management systems	Technology collaboration / Access to markets
11.		• Develop R&D centers specializing in developing supporting tools and software for efficient operation of equipment / systems	Knowledge partnership
12.	**Equipment manufacturing**	• Technology transfer/technical assistance for setting up units manufacturing energy efficient household appliances • Setting up semiconductor fabrication plant that can supply components for manufacturing smart appliances and equipment.	Investment partnership/ Technology collaboration
13.		• R&D on designing and manufacturing energy efficient equipment • Development of State-of-the art testing laboratory for manufactured products	Knowledge partnership

6.8. Priority actions – High Impact, Low Effort

Table below shows key action items with high impact potential in terms of ease of implementation, local economic growth, jobs creation and rural livelihood improvement which can be launched / continued as flagship initiatives.

- In the short term, the action plan focuses more on Policies and Institutional strengthening. The infrastructure directly under the ambit of the State Government can be first taken up for implementation of renewable energy solutions.
- Development of projects for the private sector side and creation of new markets will be undertaken in the medium term once the supporting policies and institutional mechanisms are in place.
- The recommendations on financial schemes that can have a potentially high social impact are suggested for immediate uptake.

Sr.	Sector	Priority actions
1	Industries	• Regulatory clarity on applicability of RPO on captives through amendment to OERC RPO Regulations • Demand aggregation for RE power from industries • Implementation of RE Policy to enable industries to switch to RE
2	Agriculture	• Develop and implement schemes for efficient electric and solar pumps as replacement for diesel pumps • Awareness campaigns for use of solar powered and electric equipment in all stages of food processing from seeding to harvesting to storage • Plan for renewable powered cold storages. Initially this can be done through a pilot study on a mid-sized cold storage facility. It can then be rolled out for all cold storages.
3	Fisheries	• Undertake pilot for battery operated fishing vessels charged using renewable power. Based on learnings, this can be rolled out for large number of fishing vessels. • Develop and implement schemes for replacing diesel powered fishing vessels to battery operated vessels which can be charged using renewable energy • Awareness campaigns for use of solar powered and electric equipment in fish processing stages • Plan for renewable powered cold storages. Initially this can be done through a pilot study on a mid-sized cold storage facility. It can then be rolled out for all cold storages.
4	Transport	• Aggregate demand from Government Departments to replace all vehicles older than 15 years with EVs • Plan for replacement of all old diesel buses operated by the State Transport Undertaking with EVs depending on feasibility • Selection of major cities for development of charging infrastructure and rolling out plan for setting up charging infrastructure through any of the models suggested by NITI Aayog
5	Buildings	• Selection of State Government owned facilities such as schools, hospitals, universities/colleges, hotels, government offices etc. for solarization through use of solar rooftops, solar water heaters and solar cooking apparatus. • Ensure 100% compliance with ECBC code • Plan for replacement of old, inefficient equipment (such as lighting, ACs, pumps etc.) with energy-efficient equipment
6	Energy Supply	• Undertake resource potential assessment studies for all major technologies – ground mount solar, offshore/onshore wind, floating solar, pumped storage, hydro, small hydro etc. • Implementation of RE policy to ensure development of capacity within the State • Plan for development of transmission infrastructure to integrate renewables • Blending of biomass for thermal power plants
7	Cross-sectoral	• Develop a plan for CBG production which can be used as a fuel across industries such as agriculture, transport, industries, fisheries etc. • Align the various schemes and policies such as Mission Shakti, Livelihood Mission etc. to ensure that all sectoral policies and plans focus on local job creation, women empowerment and sustainability.

7. Appendix – Assumptions

Agriculture Sector Assumptions:

Tractor Energy Demand Assumptions:

Parameters	2020	2025	2030	2035	2040
Tractors in use (%)	60%	60%	60%	60%	60%
Hours of usage	500.000	500.000	500.000	500.000	500.000
Fuel consumption per hour (Mtoe/hr)	3.35E-09	3.35E-09	3.35E-09	3.35E-09	3.35E-09
Gwy/Tractor	1.34E-06	1.34E-06	1.34E-06	1.34E-06	1.34E-06

(Source: Indian Energy Security Scenario 2047 Ver 2)

Cost Assumptions for Pumps:

	Capital Cost INRCr2020/GWy	Operational Cost INRCr2020/GWy
Diesel pump price (5HP)	0.002942057	0.000147103
Solar pump price (3HP)	0.01632	0.000816
Electricity pump price (5HP)	0.002534745	0.000126737

(Source: Indian Energy Security Scenario 2047 Ver 2)

Assumptions on Efficiency of Pumps:

Efficiency of Agriculture Pumps	2020	2025	2030	2035	2040	2045	2050
Electric Pump	36%	43%	50%	57%	64%	71%	78%
Solar Pump	36%	43%	50%	57%	64%	71%	78%
Diesel Pump	33%	39%	46%	52%	58%	64%	71%

(Source: Indian Energy Security Scenario 2047 Ver 2)

Cooking Sector Assumptions:

Household Annual Fuel Consumption

Type of fuel	Life(Years)	Yearly Consumption per HH	Lifetime Consumption(GW y)
Improved Biomass	3	1.99716E-07	5.99E-07
Coal	3	2.41306E-07	7.24E-07
Electricity	10	1.16589E-07	1.17E-06
LPG/PNG/Biogas	15	1.60868E-07	2.41E-06
Kerosene	5	9.38243E-08	4.69E-07
Traditional Biomass	1	4.6106E-07	4.61E-07

(Source: Indian Energy Security Scenario 2047 Ver 2)

Efficiency of Cooking Technologies

Efficiency of technologies	%
LPG	60%
ELECTRICITY	78%
PNG	50%
BIOMASS (improved)	27%
COAL	21%
KEROSENE	35%

BIOGAS	50%
BIOMASS (traditional)	13%

(Source: Indian Energy Security Scenario 2047 Ver 2)

Transport Sector Assumptions

Average Utilization for Passenger Vehicles

Type of Vehicle	Fuel Type	Total kilometers travelled per year					
		2020	2025	2030	2035	2040	2045
BUS	DIESEL	98391	99978	101565	103152	104739	106326
	CNG	98391	99978	101565	103152	104739	106326
	ELECTRIC	98391	99978	101565	103152	104739	106326
	FCV	98391	99978	101565	103152	104739	106326
ONMI-BUS	DIESEL	38246	39039	39833	40626	41420	42213
	CNG	38246	39039	39833	40626	41420	42213
CAR	PETROL	13924	14779	15633	16487	17341	18196
	DIESEL	13924	14779	15633	16487	17341	18196
	CNG	13924	14779	15633	16487	17341	18196
	LPG	13924	14779	15633	16487	17341	18196
	ELECTRIC	13924	14779	15633	16487	17341	18196
	FCV	13924	14779	15633	16487	17341	18196
2W	PETROL	6427	6030	5634	5237	4840	4443
	PETROL	6864	6665	6467	6268	6070	5872
	PETROL	1825	1825	1825	1825	1825	1825
	ELECTRIC	2261	2460	2658	2857	3055	3253
3W	CNG	35405	35405	35405	35405	35405	35405
	LPG	35405	35405	35405	35405	35405	35405
	PETROL	35405	35405	35405	35405	35405	35405
	DIESEL	35405	35405	35405	35405	35405	35405
	ELECTRIC	35405	35405	35405	35405	35405	35405
TAXI	CNG	37373	37770	38166	38563	38960	39357
	LPG	37373	37770	38166	38563	38960	39357
	DIESEL	37373	37770	38166	38563	38960	39357
	ELECTRIC	37373	37770	38166	38563	38960	39357
RAIL	DIESEL	59000	59000	59000	59000	59000	59000
	ELECTRIC	59000	59000	59000	59000	59000	59000
AIR	AIR	2270000	2270000	2270000	2270000	2270000	2270000

(Source: Indian Energy Security Scenario 2047 Ver 2)

Average Passenger occupancy per vehicle

Technology	Occupancy
Bus	45
Mini Bus	10

2W	2
3W	2
Car	4
Taxi	3
Airplane(P)	180
Railways(P)	1000

(Source: Indian Energy Security Scenario 2047 Ver 2)

Fuel Efficiency

Type of Vehicle	Type of fuel	Unit	2020	2025	2030	2035	2040
BUS	DIESEL	km/l	5.34	5.35	5.35	5.36	5.36
BUS	CNG	km/kg	3.75	3.75	3.76	3.76	3.77
BUS	ELECTRIC	km/kwh	1.11	1.11	1.11	1.11	1.11
BUS	FCV	km/kg	7.7	7.79	7.90	8.00	8.11
ONMI-BUS	DIESEL	km/l	7	7.01	7.01	7.02	7.03
ONMI-BUS	CNG	km/kg	10.23	10.24	10.25	10.26	10.27
CAR	PETROL	km/l	11.88	11.99	12.10	12.21	12.32
CAR	DIESEL	km/l	9.86	9.95	10.04	10.13	10.22
CAR	CNG	km/kg	32	32.32	32.65	32.98	33.31
CAR	LPG	km/kg	17.24	17.40	17.55	17.71	17.87
CAR	ELECTRIC	km/kwh	9.48	9.49	9.50	9.51	9.52
CAR	FCV	km/kg	114.95	116.70	118.48	120.29	122.12
2W	PETROL	km/l	44.51	44.55	44.60	44.64	44.69
2W	ELECTRIC	km/kwh	59.06	59.12	59.18	59.24	59.30
3W	CNG	km/kg	27	27.03	27.05	27.08	27.11
3W	LPG	km/kg	25	25.03	25.05	25.08	25.10
3W	PETROL	km/l	28.7	28.73	28.76	28.79	28.82
3W	DIESEL	km/l	36.11	36.15	36.18	36.22	36.25
3W	ELECTRIC	km/kwh	3.38	3.38	3.39	3.39	3.39
TAXI	CNG	km/kg	32	32.03	32.06	32.10	32.13
TAXI	LPG	km/kg	17.24	17.26	17.27	17.29	17.31
TAXI	DIESEL	km/l	10.24	10.25	10.26	10.27	10.28
TAXI	ELECTRIC	km/kwh	1.46	1.46	1.46	1.46	1.47
RAIL	DIESEL	km/l	0.11	0.12	0.12	0.13	0.13
RAIL	ELECTRIC	km/kwh	0.1	0.10	0.10	0.11	0.11
AIR	ATF	km/l	0.08	0.08	0.08	0.08	0.08

Energy requirement for freight transport

Energy per vehicle tonne km (TWh/vehicle-ton-km)		2020	2025	2030	2035	2040
Road						
HCV	Diesel	1.90E-10	1.90E-10	1.90E-10	1.90E-10	1.90E-10
	LNG	1.50E-10	1.50E-10	1.50E-10	1.50E-10	1.50E-10
	Electric	1.20E-10	1.20E-10	1.20E-10	1.20E-10	1.20E-10
LCV	Diesel	3.20E-10	3.20E-10	3.20E-10	3.20E-10	3.20E-10
	CNG	2.31E-10	2.31E-10	2.31E-10	2.31E-10	2.31E-10

	Electric	1.72E-10	1.72E-10	1.72E-10	1.72E-10	1.72E-10
Rail	Diesel	4.93E-11	4.93E-11	4.93E-11	4.93E-11	4.93E-11
	Electric	1.34E-11	1.34E-11	1.34E-11	1.34E-11	1.34E-11
Air	Air	2.47E-09	2.47E-09	2.47E-09	2.47E-09	2.47E-09
Shipping	Diesel	7.00E-12	7.00E-12	7.00E-12	7.00E-12	7.00E-12

Average carrying capacity of freight transport

Model	Kilometers per year	Tonnage
HCV	201,248	6
LCV	75,619	2
RAIL	2,789,588	2,830
AIR	15,377,465	17

(Source: Indian Energy Security Scenario 2047 Ver 2)

Industry Sector Assumptions:

Fuel Efficiency

Technology	Units	2020	2025	2030	2035	2040	2045	2050
Biomass	%	53%	53%	56%	56%	59%	59%	62%
Coal	%	49%	49%	54%	54%	59%	59%	64%
Electricity	%	89%	89%	90%	90%	91%	91%	92%
Gas	%	68%	68%	71%	71%	74%	74%	77%
Oil	%	59%	59%	63%	63%	67%	67%	71%
H2	%	95%	95%	95%	95%	95%	95%	95%

(Source: Indian Energy Security Scenario 2047 Ver 2)

Capital Investment

Technology	Units	2020	2025	2030	2035	2040	2045	2050
Biomass	INRCr2020/Gwy	1597	1597	1632	1632	1676	1676	1729
Coal	INRCr2020/Gwy	1062	1062	1088	1088	1123	1123	1158
Electricity	INRCr2020/Gwy	307	307	316	316	316	316	333
Gas	INRCr2020/Gwy	605	605	623	623	641	641	658
Oil	INRCr2020/Gwy	658	658	667	667	684	684	702
H2	INRCr2020/Gwy	605	605	623	623	641	641	658

(Source: Indian Energy Security Scenario 2047 Ver 2)

SEC reduction of industry sub-categories

SEC (toe/Tonne)	Unit	2020	2025	2030	2035	2040
Cement (Mtoe/MMT)	toe/Tonne	0.083	0.079	0.071	0.064	0.058
Fertilizer (Mtoe/MMT)	toe/Tonne	0.579	0.579	0.531	0.507	0.484
Aluminium (Mtoe/MMT)	toe/Tonne	5.118	4.924	4.339	3.950	3.560
Iron and Steel (Mtoe/MMT)	toe/Tonne	0.610	0.590	0.532	0.493	0.454
Pulp and Paper (Mtoe/MMT)	toe/Tonne	0.875	0.741	0.557	0.398	0.239
Textile (Mtoe/MMT)	toe/Tonne	0.790	0.780	0.707	0.665	0.623

Chlor Alkali (Mtoe/MMT)	toe/Tonne	0.830	0.810	0.734	0.686	0.638
Others(Mtoe/INR Trillion)	Mtoe/INR trillion	9.113	8.744	7.000	5.944	4.887
Petrochemicals (Mtoe/MMT)	toe/Tonne	0.558	0.537	0.474	0.433	0.391

(Source: Indian Energy Security Scenario 2047 Ver 2)

Buildings Sector Assumptions:

Energy consumption for each type of technologies in buildings

Wattage (GW)	2020	2025	2030	2035	2040
Lighting					
Bulb	6.00E-08	5.55E-08	5.10E-08	4.65E-08	4.20E-08
Tube-light	2.80E-08	2.59E-08	2.38E-08	2.17E-08	1.96E-08
CFL	1.50E-08	1.39E-08	1.28E-08	1.16E-08	1.05E-08
LED	8.00E-09	7.40E-09	6.80E-09	6.20E-09	5.60E-09
Television					
Low Efficiency	8.10E-08	7.34E-08	6.57E-08	5.81E-08	5.04E-08
Medium Efficiency	6.00E-08	5.43E-08	4.86E-08	4.28E-08	3.71E-08
High Efficiency	4.50E-08	4.01E-08	3.51E-08	3.02E-08	2.52E-08
Refrigerator (Mtoe/ year)					
Low Efficiency	3.87E-08	3.47E-08	3.08E-08	2.68E-08	2.29E-08
Medium Efficiency	2.34E-08	2.09E-08	1.83E-08	1.58E-08	1.32E-08
High Efficiency	1.63E-08	1.45E-08	1.27E-08	1.09E-08	9.03E-09

(Source: Indian Energy Security Scenario 2047 Ver 2)

Penetration of efficient technology for commercial buildings

Percentage of Appliance Penetration	2020	2025	2030	2035	2040
Lighting					
Bulb	40%	31%	23%	14%	6%
Tubelight	11%	9%	7%	4%	2%
CFL	9%	8%	6%	5%	3%
LED	40%	52%	65%	77%	89%
Appliances (Television/ Refrigerator/ etc.)					
Low Efficiency	41%	37%	33%	28%	24%
Medium Efficiency	36%	36%	36%	36%	36%
High Efficiency	23%	27%	32%	36%	40%

(Source: Indian Energy Security Scenario 2047 Ver 2)

Penetration of Efficient Technologies in Residential Buildings

Appliances	Variants	Penetration of efficient technologies				
		2020	2025	2030	2035	2040
Lighting	Bulb	40%	31%	23%	14%	6%
	Tube-light	11%	9%	7%	4%	2%
	CFL	9%	8%	6%	5%	3%

	LED	40%	52%	65%	77%	89%
Ceiling Fans	Low Efficiency	41%	37%	33%	28%	24%
	Medium Efficiency	36%	36%	36%	36%	36%
	High Efficiency	23%	27%	32%	36%	40%
Televisions	Low Efficiency	41%	37%	33%	28%	24%
	Medium Efficiency	36%	36%	36%	36%	36%
	High Efficiency	23%	27%	32%	36%	40%
Refrigerators	Low Efficiency	41%	37%	33%	28%	24%
	Medium Efficiency	36%	36%	36%	36%	36%
	High Efficiency	23%	27%	32%	36%	40%
Room Air-conditioners	Low Efficiency	41%	37%	33%	28%	24%
	Medium Efficiency	36%	36%	36%	36%	36%
	High Efficiency	23%	27%	32%	36%	40%

(Source: Indian Energy Security Scenario 2047 Ver 2)

Appliance Penetration in Residential Buildings

Percentage of Appliance Penetration	2020	2025	2030	2035	2040
Lighting					
Bulb	40%	31%	23%	14%	6%
Tube-light	11%	9%	7%	4%	2%
CFL	9%	8%	6%	5%	3%
LED	40%	52%	65%	77%	89%
Appliances (Television/ Refrigerator/ etc.)					
Low Efficiency	41%	37%	33%	28%	24%
Medium Efficiency	36%	36%	36%	36%	36%
High Efficiency	23%	27%	32%	36%	40%

(Source: Indian Energy Security Scenario 2047 Ver 2)

Capital Investment Cost for Different Technologies:

Technology	Unit	2020	2025	2030	2035	2040
Biomass-Gas Plant	**INRCr/GW**	25000	25000	25000	25000	25000
Biomass-Electricity Plant	**INRCr/GW**	6520	6520	6520	6520	6520
Coal SC	**INRCr/GW**	7700	7700	7700	7700	7700
Coal sub-critical	**INRCr/GW**	7500	7500	7500	7500	7500
Coal USC	**INRCr/GW**	27941	27506	27078	26657	26242
Coal USC_ccs	**INRCr/GW**	45773	44462	43189	41953	40752
Gas Combined Cycle with CCS	**INRCr/GW**	20125	19086	18101	17167	16281
Gas Combined Cycle power plant	**INRCr/GW**	10901	10605	10318	10039	9767
Gas Engine power plant	**INRCr/GW**	7206	7563	7919	8276	8632
Hydro Power plant	**INRCr/GW**	11200	12400	13600	14800	16000
IGCC power plant	**INRCr/GW**	31439	30548	29682	28841	28024
IGCC power plant_ccs	**INRCr/GW**	45945	44630	43352	42111	40905
Nuclear Power plant	**INRCr/GW**	11700	13942	16614	19798	23592
Diesel power plant	**INRCr/GW**	5704	5704	5704	5704	5704
Small Hydro Power Plant	**INRCr/GW**	9000	9000	9000	9000	9000

Solar CSP	**INRCr/GW**	37703	30784	25135	20523	16757
Solar PV	**INRCr/GW**	4500	4500	4500	4500	4500
Wind Offshore	**INRCr/GW**	35657	32864	30290	27917	25730
Wind Onshore	**INRCr/GW**	6000	6000	6000	6000	6000
Solar PV Rooftop	**INRCr/GW**	13926	13523	13255	13052	12906
Electricity T&D	**INRCr/GW**	72	71	70	69	69
CNG Generator	**INRCr/GW**	7678	7678	7678	7678	7678
Solar Water Heater	**INRCr/GW**	2629	2606	2592	2592	2592
Wind onshore offgrid	**INRCr/GW**	9961	9883	9759	9596	9473
Diesel Generator	**INRCr/GW**	5704	5704	5704	5704	5704
H2 (Coal)	**INRCr/GWa**	2702	2267	1903	1597	1340
H2 (Gas)	**INRCr/GWa**	4877	4259	3719	3248	2837
H2 (Elec)	**INRCr/GWa**	13655	11925	10414	9095	7943
H2 (CBG)	**INRCr/GWa**	11041	11041	11041	11041	11041

Investment Calculation for Electric Pumps

Aggressive scenario			
	2025	**2030**	**2040**
Agriculture(Pump,Elec)	1002403.813	764607.375	458390
Agriculture(Pump,Oil)	85266.88281	46940.85547	0
Agriculture(Pump,Solar)	198948.0625	351968.7188	458390
	1286618.758	1163516.949	916780
Penetration	10%	40%	50%
Targets	128661.8758	465406.7797	458390
Net cost (INR Crores)	484.7979481	1753.652746	1727.21352
Power savings	9.598175937	34.71934577	34.195894
Cost savings / year (INR Crores)	54.3256758	196.511497	193.54876
Electric pump cost (INR Crores)	3777	2881	1727

Decarbonization scenario			
	2025	**2030**	**2040**
Agriculture(Pump,Elec)	904169.75	603048.25	228839.0781
Agriculture(Pump,Oil)	85266.88281	46940.85547	0
Agriculture(Pump,Solar)	393413.2813	699209	971628.125
	1382849.914	1349198.105	1200467.203
Penetration	30%	50%	65%
Targets	414855	674599	780304
Net cost (INR Crores)	1563.173543	2541.889231	2940.184274
Power savings	30.94818108	50.32508933	58.21065468
Cost savings / year (INR Crores)	175.1667049	284.8400056	329.4723055
Electric pump cost (INR Crores)	3407	2272	862

Investment Calculation for Solar Pumps

Aggressive scenario			
	2025	**2030**	**2040**

Agriculture(Pump,Elec)	1002403.813	764607.375	458390
Agriculture(Pump,Oil)	85266.88281	46940.85547	0
Agriculture(Pump,Solar)	198948.0625	351968.7188	458390
	1286618.758	1163516.949	916780
Solar pump percentage	15%	30%	50%
Total cost of solar pumps (INR Crores)	8,038	14,220	18,519
Annual interest (INR Crores)	161	284	370
Annual diesel savings (INR Crores)	2,686	4,752	6,188
Operating cost (INR Crores)	402	711	926
Cost savings (INR Crores)	2,123	3,756	4,892

Decarbonization scenario			
	2025	**2030**	**2040**
Agriculture(Pump,Elec)	904169.75	603048.25	228839
Agriculture(Pump,Oil)	85266.88281	46940.85547	0
Agriculture(Pump,Solar)	393413.2813	699209	971628.125
	1382849.914	1349198.105	1200467.203
Solar pump percentage	28%	52%	81%
Total cost of solar pumps (INR Crores)	15,893.90	28,248.04	39,253.78
Annual interest (INR Crores)	317.88	564.96	785.08
Annual diesel savings (INR Crores)	5311.079298	9439.3215	13116.97969
Operating cost (INR Crores)	794.69	1,412.40	1,962.69
Cost savings (INR Crores)	4,198.51	7,461.96	10,369.22

Calculation of Spending on Electric Cookstove by a Customer

		Monthly payment (INR)												
Electric Cookstove	**Down-payment assumed (INR)**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**Total Amount at the end of the year**
1400 W electric stove	8000	504	504	504	504	504	504	504	504	504	504	504	504	14048
2100 W electric stove	8000	756	756	756	756	756	756	756	756	756	756	756	756	17072

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